Faculty of Mechanical Engineering

THERMAL INSULATION MATERIAL MADE FROM KENAF COMPOSITE

Nursahira Binti Rofii

Bachelor of Mechanical Engineering

2018

DECLARATION

I declare that the project “Thermal insulation material made from kenaf composite” is the paperwork of my own work except for the citied stated in the references.

Signature : ……………………………...

Name : ………………………………

Date : ………………………………

DEDICATION

To my beloved mother, Puan Salinah Abas

And my beloved father, Encik Rofii Bin Hussein

APPROVAL

I hereby declared that I have read this report and in my suggestion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

Signature : ……………………………......

Supervisor's Name : ………………………….........

Date : ………………………….........

ABSTRACT

Malaysia is a hot-humid country that need a very good material to act as the thermal insulator for building. Previously, the material such as brick is use as the wall for the building. However, it lead to the thermal comfort issues to human. Due to that, the manufacturer company create a product that can solve the thermal comfort issue. A combination of polymer matrix and the natural fibre is designed and become a trending in the market. Kenaf is one of the natural fibre that are expected to be a good thermal insulator for the houses and buildings. However, the kenaf cannot be produce alone. Due to that the polymer matrix such as the polypropylene is applied to produce a good composite material. The kenaf composite is fabricated using the major machine such as the internal mixer, the crusher and the hot-press machine. The fibre ratio is divided into polypropylene and kenaf powder of 50:50, 60:40, 70:30, 80:20.

The fabrication process is divided into different fibre ratio of kenaf powder and the polypropylene. In this report, three test is conducted in order to investigate the quality of the kenaf composite to be used as a thermal insulator. The test are covering the mechanical and the thermal properties. The three test have been conducted are the thermal conductivity test, the water absorption test and the hardness test on the kenaf composite. The investigation on the three tests can give the best fibre ratio of the specimen that can perform as a good thermal insulator. For the thermal conductivity testing the best k value obtain is 9.74. While for the absorption testing, the preferred moisture content is 10.07%. For the hardness testing is highest at the 71.27. From the result, can be concluded that the best ratio that need to be used is the 50:50 fibre ratio.

The kenaf-polypropylene composite is suited for thermal insulation application in the building. As a conclusion, the kenaf-polypropylene composite is recommended as a good thermal insulator due to the low thermal conductivity value and environmental friendly.

ABSTRAK

Malaysia merupakan engara panas lembap yang memerlukan bahan yang bagus untuk bertindak sebagai penebat haba di dalam bangunan. Sebelum ini bahan seperti batu bata digunakan sebagai dinding untuk bangunan. Walaubagaimanapun, ianya menimbulkan masalah keselasan kepada manusia. Oleh itu, syarikat pengeluar telah mencipta sebuah produk yang boleh menyelesaikan isu kelesaan suhu ini. Gabungan bahan matrik polimer dan serat semulajadi telah dicipta dan semakin popular di dalam pasaran. Kenaf merupak satu serat semulajadi yang dijangka boleh menjadi suhu penebat yang baik untk perumahan dan bangunan. Tetapi, kenaf tidak boleh dihasilkan secara bersendirian. Disebabkan itu, kenaf perlu dicampurkan dengan matriks polypropylene (PP) untuk menghasilkan bahan komposit yang baik. Komposit Kenaf akan di hasilkan mengunakan mesin utama seeprti campuran dalam mesin, mesin hancur dan mesin tekanan panas.

Penghasilan Kenaf akan dibahagikan kepada beberapa nisbah serbuk kenaf dan Polypropylene. Di dalam laporan ini, sebanyak tiga ujian akan diadakan untuk mengetahui kualiti kenaf komposit sebagai suhu penebat. Ujian tersebut akan merangkumi ujian mekanikal dan ujian suhu. Tiga ujian yang akan disediakan ialah ujian kekonduksian suhu, ujian penyerapan air dan ujian kekerasan bahan. Siasatan keatas ketiga-tiga ujian ini akan memberi solusi nisbah yang terbaik untuk dijadikan sebagai suhu penebat.

Sifat-sifat suhu penebat yang baik akan dikaitkan dengan ketiga-tiga ujian yang diadakan ini. Dengan membandingkan dengan bahan kajian yang lepas, analisis data boleh dilakukan dan nisbah Kenaf composit yang terbaik akan dipilih sebagai suhu penebat.

ACKNOWLEDGEMENTS

It is a really great opportunities for students especially the final year students of the Mechanical engineering course to experience the Final Year Project (FYP) process. Due to that, I am very thankful and felt very lucky to be part of it. I am also looking forward to work along with the great and exciting people in order to complete the project. I am realised that it is not easy to get the opportunities to work with the great people.

First and foremost, I would like to give my greatest gratitude to God for giving me the chance and strength to complete the Final Year Project at a given duration. With God willing I manage to complete the project with fully satisfaction. Next, I would like to offer my gratitude to the high committee of the JK-PSM organization for helping us in organize our schedule so that the projects can be completed. The JK-PSM organization also always give a useful information regards the final year projects when needed. I am so thankful to have an organization that always guide us to complete the project perfectly.

After that, the biggest gratitude is given to my one and only supervisor En Shamsul Bahari B Azraai for spending his precious time and effort to help me on completing the projects. I also very thankful for the precious guidance that extremely valuable given by my supervisor throughout the study.

I would also like to give my full gratitude to my project examiners for always sharing the useful information. Their guidance help me to perform better in future. Last but not least, the gratitude are offer to my family and friends for always encouraged and supporting me to complete the project. The time, effort and the money that they have spent for me cannot be repay.

TABLE OF CONTENTS

PAGE

DECLARATION **ii**
DEDICATION **iii**
APPROVAL **iv**
ABSTRACT **v**
ABSTRAK **vi**
ACKNOWLEDGEMENTS **vii**
TABLE OF CONTENTS **ix**
LIST OF TABLES **x**
LIST OF FIGURES **xi**
LIST OF APPENDICES **xiv**
LIST OF ABBREVIATIONS **xv**

CHAPTER

1. INTRODUCTION

1.1. Background Study 1
1.2. Problem Statement 2
1.3. Objective 4
1.4. Scope of Project
1.4.1. Fabrication 4
1.4.2. Testing 5
1.4.3. Analysing Data 5
1.4.4. Comparison 5

2. LITERATURE REVIEW
2.1. Kenaf and Thermal Insulation 6
2.2. Thermal Conductivity (k) 8
2.3. Water Absorption 10
2.4. The hardness testing 11

3. METHODOLOGY
3.1. Introduction 14
3.2. Research and studies 16
3.3. Materials
3.3.1. Kenaf and Polyproplyene (PP) 17
3.4. Composite Preparation
3.4.1. Internal mixture 19
3.4.2. Crusher machine 20
3.4.3. Hot-press machine 22
3.4.4. Product 1 25
3.5. Thermal Conductivity Test 26
3.6. Water Absorption Test 27
3.7. The Hardness testing 28

4. RESULTS AND DICUSSION
Experiment Testing
4.1. Thermal conductivity 30
4.2. Water Absorption testing 35
4.3. Hardness testing 40

5. CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH 48

REFERENCE 50
APPENDIX 54

LIST OF TABLES

TABLES	TITLE	PAGE
1.1	Fibre Ratio	4
4.1	WA testing 50:50	31
4.2	WA testing 60:40	31
4.3	WA testing 70:30	32
4.4	WA testing 80:20	32
4.5	Hardness testing 50:50	40
4.6	Hardness testing 60:40	41
4.7	Hardness testing 70:30	41
4.8	Hardness testing 80:20	42

LIST OF FIGURES

FIGURES	TITLE	PAGE
1.1	Kenaf Fibre	2
1.2	The building envelope	3
1.3	The building envelope entities	3
2.1	The thermal insulation	7
2.2	The effect of density and thermal conductivity	8
2.3	Heat flow meter schematic diagram	9
2.4	Hardness testing	12
3.1	Flow work	15
3.2	Kenaf powder	17
3.3	Polypropylene	18
3.4	Composite product	19
3.5	Internal Mixer Schematic Diagram	20
3.6	Crusher Schematic Diagram	21
3.7	crushing process	21
3.8	Granule composite material	22

3.9	20x10x0.3cm mold	22
3.10	Cylinder mold	23
3.11	Air bubble trap	23
3.12	Hole on mold	23
3.13	Mycut CNC plasma	24
3.14	Hot press machine schematic diagram	25
3.15	20x10x0.3 c product	25
3.16	Cylinder product	26
3.17	The setup of Infrared Lamp and Gun	27
3.18	Water Absoprtion testing	27
3.19	Schematic diagram beakers and dry oven	28
3.20	Hardness durometer testing	28
3.21	Schematic diagram durometer	29
4.1	Temperature changes 50:50	31
4.2	Temperature changes 60:40	31
4.3	Temperature changes 70:30	32
4.4	Temperature changes 80:20	32
4.5	Relationship thermal conductivity	33
4.6	Relationship immersion and weight change	37
4.7	Moisture content and different fibre ratio	39

4.8	Shore D hardness scale	43
4.9	Hardness strength of kenaf	43
4.10	Relationship density and fibre ratio	44
4.11	Comparison experiment and journal	44

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
1	Fabrication process	54
2	Thermal conductivity testing	55
3	Water Absorption testing	56
4	Hardness testing	56
5	Gantt chart	57

LIST OF ABBREVIATIONS

ABBREVIATION	TITLE	PAGE
PP	Polypropylene	4

LIST OF SYMBOLS

TABLES	TITLE	PAGE
K	Thermal conductivity	30
Q	Heat transfer	26

CHAPTER 1

INTRODUCTION

1.1 **Background Study**

Kenaf fibre is natural fibres that become more popular in the industry. It is highly demanded by many company. Many company demand for it due to its lightweight and environmentally sustainable materials (Siew *et al.* 2017). It is because Kenaf can give a lot of benefit compare to the exist material that has been used in construction. A few study is conduct to investigate the quality of Kenaf as a thermal insulator. Kenaf is a fibre plant native to the east Africa. Kenaf is discovered to replace the existence brick that has been used for the construction. To produce a solid Kenaf product, a few process need to be done. Kenaf will mix together with the Polypropylene according to the weightage percentage for each material.

The study on the Kenaf as the insulator are conduct due to its advantage in the construction field. From the journal stated that Kenaf can improving the mechanical strength. The addition of Kenaf in Polypropylene lead to the higher flexural strength. Kenaf also has high cellulose content and also has good micro fibrils orientation that can lead to the high flexural modulus.

By applying the Kenaf also can help to control the environmental issues. Kenaf is a fibre that very easy to control. It is because Kenaf has a short plantation cycle and the amount of pesticide requires are less (Siew *et al.* 2017). Temperature gives big influence in the thermal stability of the Kenaf (Siew *et al.* 2017). So, the temperature in the building can be consistence from day to night when Kenaf is used. For the study, a few test such as the thermal conductivity test and water absorption will be carry out in order to know the ability of the Kenaf as a thermal insulator.

This study is very important to our country because it can give benefit to us and also can help us in exporting the local product and make our economy become better.

Figure 1.1 :Kenaf fibre

1.2 **Problem Statement**

Malaysia is a country with tropical climate that sunny during day and cool during night. So, the heat from the sun radiation can give impact to the building in Malaysia. From year to year, many development had happened in terms of the thermal insulation. From one material to others. For now, mostly in building development, barrack or cement is used as the material.

Normally, the building thermal represent the energy consumption (Wang *et al* 2009). In order to save the building energy consumption for the comfort, the thermal performance of building envelope need to be improved (Wang *et al*. 2009). The four factors to get the thermal comfort are the envelope design, natural cooling sources, hybrid cooling system and adapting lifestyle.

The crucial factors that give effect to the envelope design is the climate (E.M. Okba ,2005). For the building envelope in Malaysia, during day, 70% of the sun radiation is absorbed by the ceiling and 30% are absorbed by the wall. The material used keep the absorbed heat until night. The problem occur when, at night, the heat will be released into the building. So, the room temperature will be increase higher. It lead to the people inside the building feel uncomfortable. Mostly, they will start using the air conditioner to feel more comfortable which is not good for our mother earth.

Materials that surrounds the building give crucial role as a protection. Good care must be taken when choosing the material for every parts in the building envelope (E.M Okba , 2005). Due to that, a non-woven material such as Kenaf that become popular lately is suggested to be used as the material for the ceiling and wall for the building. It is because the Kenaf function better than the other material when it comes to the thermal insulation. Kenaf material will make people feel more comfortable at night because the percentage heat absorbed is less than usual.

So, three test have been conducted for the Kenaf on the thermal and mechanical properties to know the ability of Kenaf to be good material for themal insulator.

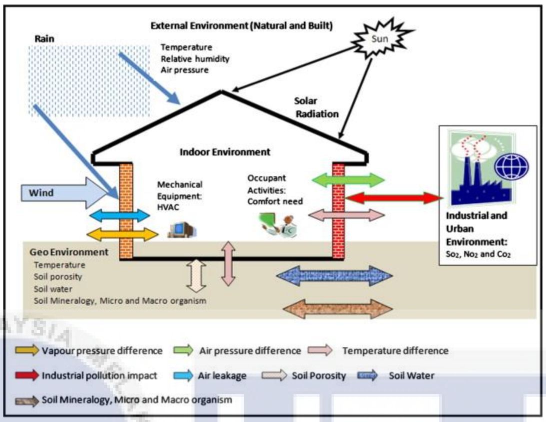


Figure 1.2 : The building envelope

The building envelope made up of structural materials such as walls, roofs, windows and doors (E.M Okba, 2005). The envelope is very important because it functioned to protect the indoor environment from any changes in weather from outdoor environment (Rivard *et al.* 1999). The building is made up of a few parts such as the envelope planes, envelope areas, envelope sections, envelope layers, openings, connections, and indoor (Rivard *et al* 1999).

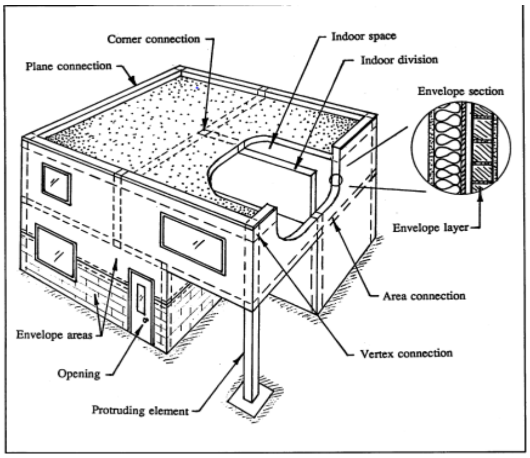


Figure 1.3 : The building envelope entities

1.3 Objective

For this study, we will be focus on three type of study. The three study will be focus on the thermal properties only. To be good as thermal insulator, Kenaf composite must be test to know the level of the quality. To make sure our experiment is success, four guidelines is set up as the objective. The objectives of this study are :

1. To determine out the thermal conductivity value (k) for Kenaf/PP composite.
2. To analyze the water absorption on the Kenaf/PP composite.
3. To investigate the hardness on the Kenaf/PP composite.
4. To compare the experimental with the findings from previous researchers

1.4 Scope of Project

In order to get a good and accurate results, there are a few scope that need to be focus on. For the project, we focus on the four scope that surely can give a good result for experiment that had been carried out. These procedure need to be followed to avoid wasting much time in doing the testing.

1.4.1 Fabrication

The first step that need to be done is fabricate the Kenaf fibre to be the suitable material for the experiment. The raw material which is the Kenaf fibre will be undergo a few experiment in order to get the exact material. As we know, Kenaf is a natural fibre is mixed with the polypropylene (pp) in a internal mixture in order to produce the Kenaf composite. There are different proportion of the Kenaf and PP mixture that need to be fabricate for every test. The amount of both mixtures are set to 100%. However, the percentage of the polypropylene must be higher or equal to Kenaf. Percentage of Kenaf cannot be higher than PP.

Table 1.1 : fibre ratio

Percentage Weightage	
Kenaf	Polypropylene (PP)
20	80
30	70
40	60
50	50

1.4.2 Testing

Next scope will be focus on the test. Refer to the objective, three guidelines are stated in order to achieve a good result. Due to that, the test will be carry out using different method to investigate the quality of the Kenaf as a thermal insulator. The three test that will be carry out are the thermal conductivity test (k-value), the hardness test and also the water absorption test. The data from each experiment will be record as a references and comparison.

1.4.3 Analysing data

After the test are carried out, the data are used to be analyse. The data obtain can be as a benchmark for our test. For each test will give a different data and we can draw a few conclusion for it. The data act as the solid prove of the experiment that has been carried out. It need to analyse in order to call the experiment as a success or not.

1.4.4 Comparison

To get more accurate result, the data than has been obtained need to be compare with the theoretical value that we find from the journal and previous research. By comparing the data, we can know that the value that we get is correct and can be use officially. By comparing the result, we can also know whether Kenaf is a good thermal insulator or not.

CHAPTER 2

LITERATURE REVIEW

2. 1 Kenaf and Thermal Insulation

In the modern life, the natural fibre such as Kenaf , banana and others have been use widely in order to control the thermal comfort and also the environment. Since years, in every technology aspect, environmental issue is a crucial issues (Lee *et al.* 2017). For this experiment, Polypropylene (PP) is mixed with the Kenaf fibre to be produce as a composite materials. Kenaf and PP composite show better in flexural properties compared to other natural fibre/PP composite. According to N. S. Suharty, this is due to the high number of cellulose content in the Kenaf fibre (Lee *et al*. 2017). Asumani et al 2012 conduct a study on the chemical bonding and find out that the alkali-silane treatment to the composite cause the tensile and the flexural properties better than other composites (N I S Anuar *et al* 2017).

Kenaf or *Hibiscus cannabinus L,* is originates from Africa and belongs to Malvaceae family (X.H Loh *et al* 2016). Kenaf is a crop that full of benefits. It has a good ability in CO2 absorption (X.H Loh *et al* 2016). Kenaf has a short period of plantation cycle and it growth in a fast rate (S.S Chee *et al.* 2017). Kenaf also has a low cost which is really need by all company (Natsuno Nishimura *et al.* 2017). According to K.K. Chawla (2011), Kenaf do not give harm to human health.

The natural fibre has become highly demanded in almost every sector because the natural fibre composite has better specific properties compare to other synthetic (N I S Anuar *et al* 2017). Besides the advantage in mechanical properties, Kenaf also has limited thermal stability which is good to act as a thermal insulator (X.H. Loh *et al.* 2016). Kenaf also offer other benefit such as odourless, lifelong time, noise insulation and attractive (X.H Loh *et al* 2016). According to some published report in December 2015, annual growth rate (CAGR) of the natural fibre market increase by 8.2% from 2015 to 2020 (S.S Chee *et al.* 2017). However, S. S. Chee *et al* (2017) stated that Kenaf has its own weakness such as the interfacial bonding between hydrophilic fibres and hydrophobic polymer is weak. This is due to the hydrophilic nature of the fibre.

Recently, the natural fibres are high demanding compare to the synthetic fibres. It is because of its advantages in every aspect especially in the automotive field due to the thermal properties (V. G. Yachmenev *et al.* 2004). Besides that, Kenaf composite also act as a good thermal insulator compare to the glass and bricks. According to S. S.Chee *et al.* (2017), the temperature gives a big impact on the thermal stability of the Kenaf composite. Kenaf can act as a good thermal insulator when the thermal stability is constant.

Malaysia is a hot-humid country and the temperature in the day can exceed 30 degree celcius. F. S. Westphal et al. (2011) conduct a study on the use of thermal insulation in a building envelope. The data is collected through a computer simulation. From the data, the result show that for building that has low load densities, the building envelope gives big influence on the cooling energy consumption. F. S Westphal et al. (2011) also stated in his journal that, in a hot country, the heat absorb through conduction can be reduce by using the thermal insulation in the building envelope.

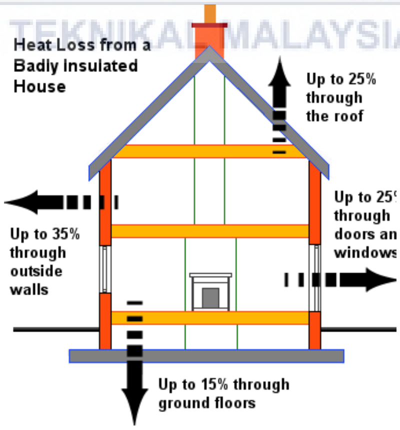


Figure 2.1 : The thermal insulation system (resource : lowenergyhouse.com)

2.2 Thermal Conductivity (k)

Thermal conductivity is to know the ability of the heat transfer for a specimen. There are method can study the relationship of the density and the thermal conductivity. From past studies show that the thermal conductivity is inversely proportional to the density. In the journal stated that during the process, the thermal conductivity is control the heat transfer rate by the bulk material. As notice, in the building, thermal properties such as the conductivity, the environmental performance and the energy performance is highlighted. From pervious study of Kiran et al and Mounika et al prove that there are strong relation between the fibre volume fraction and the conductivity. In this studies, natural fibre use is bamboo composite. For the testing, a hot disk thermal constants analyser is use to measure the conductivity (Darshil U Shah *et al.* 2016).

From Darshil U Shah et al (2016) journal also observe that in order to know the thermal conductivity, the specific heat capacity and the density must be known. From the hot disk measurement, the conductivity obtained is range from 0.20 to 0.35 W/m.K. by different type of coating, the hypothesis that the density of the material affected the thermal conductivity is valid. This is due to the changes in the proportion of the cell wall material. In figure , the result of different specimen can be observe. The graph show that different specimen give different k value.

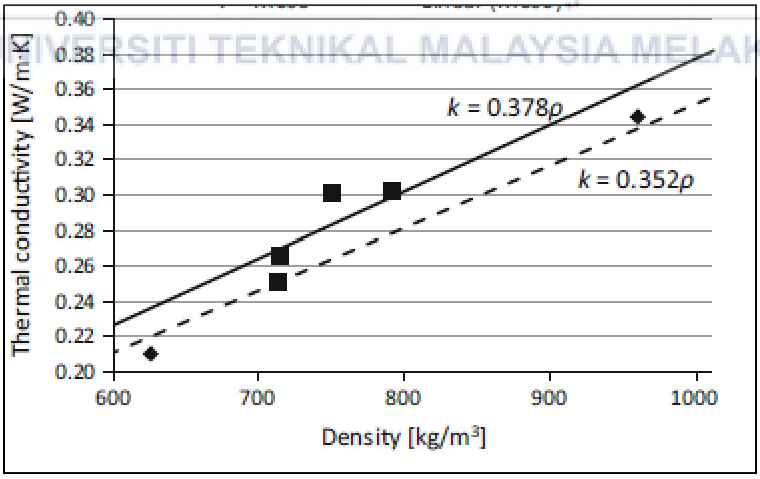


Figure 2.2 : The effect of density on conductivity.

When the maleated polypropylene is added, the thermal conductivity increased by 10 to 15 %. The range of the thermal conductivity recorded is between 0.05 to 0.07 W/m.K. the journal mentioned that, the bonding between the thermoplastic polymer and natural fibre is poor due to the different chemical nature. As informed, the polymer is hydrophobic while the natural fibre give the hydrophilic behaviour. In most journal, the heat flow meter is used for measurement. Figure 2.3, show the schematic diagram of the apparatus (Darshil *et al.* 2016).

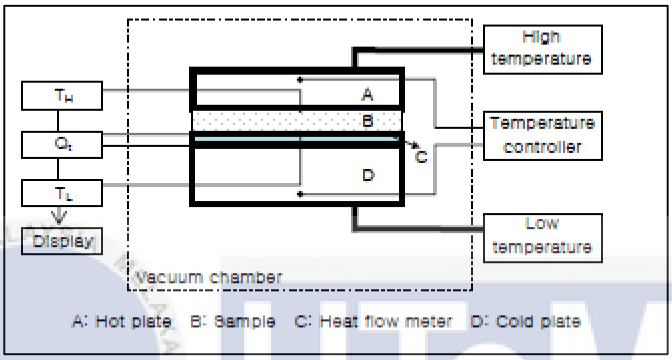


Figure 2.3: Heat flow meter Schematic diagram

From the experiment conduct by S W Kim et al. , the result obtain shows that the thermal conductivity is increase when the temperature is increase. By adding the coupling agent, the thermal conductivity value is increased.

In the Monika et al. (2013) journal focus on the method to conduct the experiment, a HT10x heat transfer service unit and HT11 heat conduction is used in order to obtain the conductivity value. The HT10x can be used to measure the heat transfer in a small scale. For the experiment the HT10x is connected to the HT11 linear heat conduction. The temperature detection and the measurement of the heat flow help to calculate the thermal conductivity of the composite. The heat and cooling flow is control the HT10x service unit.HT11 can minimize the changes of the water pressure because it has pressure regulator.

The kenaf/pp specimens is put between the heating and the cooling section of the HT11. To limit the heat resistance transition, the contact surface is cover with thermal conductive paste thin layer. There are 8 thermocouples attached to the HT11 linear heat conduction machine. It is to measure the gradient of the temperature. The water is supply through the inlet valve in order to cooling the HT11(Monika *et al.*2013).

2.3 Water Absorption

Water absorption is one of the test or experiment that will be conduct in order to know the amount of water absorb when different proportion of Kenaf powder and PP is applied. Due to W.H Haniffah et al. (2015) journal, the water uptake in the Kenaf composite can cause limitation in the outdoor application. This is due to the combination of the hydrophilic nature of the fibre and hydrophobic polymer that incompatible (A. L. Pang *et al.* 2013). The amount of water absorb cause the fibre to swelling. The hydrophilic behaviour of the Kenaf cause the water to ingrain more into the micro cracks (Nosbi *et al.* 2011). The shape and the dimension also will change. When these characteristic changes, it cause the adhesion between the polymer and fibre become poor (A. L Pang *et al.* 2013).

Reference from W. H. Haniffah et al. (2015) journal, stated that the tensile properties of the Kenaf will be change when the immersion time is changes. It is show that the fluid can give effect to the uses of the Kenaf composite. Previously, the studies conducted with comparing for three different liquid (N. Nosbi *et al.* 2011). From the Ai Ling Pang et al. (2013) journal shows that the amount of water uptake directly proportional to the immersion time. The same findings also comes from other studies (Santiagoo *et al.* 2011).

Z. Salleh et al. (2012) studies show that the water uptake amount is obtained by using the liquid content equation. Some of study such as journal from Norlin Nosbi et al.(2011), using difference in the pH value cause the the Kenaf to act different. It stated that the kenaf fibre will absorb more liquid when the pH is increase. From theory, the fibre that high in lignin content will absorb less water due to the hydrophobic behaviour (N. Nosbi *et al.* 2011).

The water absorption test was conducted using the ASTM D 570 code (Z. Salleh *et al*. 2012). According to the M. Ramesh study, he stated that for the water absorption test, a few standard need to be follow such as the composite must immersed into water for 24 hour. The mass and the dimension is recorded. Follow to the journal conduct by Norlin Nosbi et al. (2011), the water absorption test is obey the Fickian’s behaviour.

2.4 Hardness test

A few journals had proved that the hardness test is using the shore D durometer tools. From N.S Venkatesha et al (2016) journal, the testing for the mechanical properties are conduct for the natural fibre which is hemp and also the polymer. It stated that the percentage of reinforcement use are differ and the result obtained will be compare by the material proportion. From the journal, can be find out that the hardness of the composite is related to the tensile and flexural strength of the composites. The journal also mentioned that, for tensile and flexural test, the values are the highest at the composite with higher proportion of natural fibre. The hardness of each specimen also varies. The result of the journal prove that the hardness value of the composite is directly proportional to the weightage of the fibre.

For the hardness testing, the shore D is used because it can measure the plastic resistance towards the indentation. As mention, the higher fibre loading lead the tensile and flexural test lead strength increase. However, if the fibre loading are the same with the matrix, the strength will become lesser. This is because the weightage of the fibre do not sufficient to restrain the polymer matrix. This condition also can explained the hardness of the composites. The hardness strength will be greater when the proportion of the natural fibre is higher. There are few factor that had been stated such as the density, the nature bonding and the consistency of the polymer matrix (Venkatesha *et al.* 2016).

Next, from the journal of S Th Georgopoulos et al (2005), there are a lot study on the hardness test by using the durometer scale Shore D. however, the journal composite are made up of thermoplastic polymer and natural fibre. It still can be used because same equipment is used. Based on the study, ASTM D 2240 specification is use for the shore D hardness testing. The amount of 10 measurement is recorded for the test so that it will be easy to plot the graph.

Previously, a similar research are done by Meyers and Gonzales and resulted that the mechanical properties of the composites are affected by the thermal degradation. From the research of Takase and Shiraishi also prove that the mechanical properties is changes when the co-extrusion of the composite at temperature 0f 250ºC.

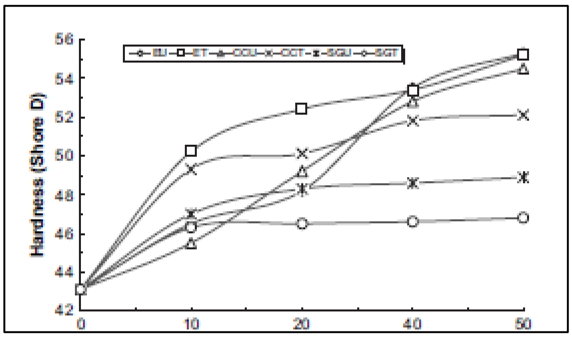


Figure 2.4 : The hardness reading (Shore D)

From figure 2.4, show a result on hardness testing on different proportion of the natural fibre and the polymer matrix in a composite. As expected the higher the fibre loading, the greater the hardness strength. This is due to the lignocellulosic filler of the fibre offer greater hardness than the polymer. As mention the hardness strength are related to the tensile properties which is the statement is truth. When the hardness values are changes, the tensile properties also will change depends on the composite proportion (S Th Georgopoulos *et al.* 2005).

For the hardness testing in the Y A El-Shekeil et al. (2012) journal, the hardness Shore D is used. The same specification as other research also use for the testing which is the ASTM D2240. But for this study, the size of the specimen is set 4x5x0.3 cm.The experiment carried out by comparing the specimen with and without the presence of the natural fibre. The result of the study show that the hardness reading of the pure polymer is stated as 55. However when the natural fibre is add together with the polymer and act as a composite, the hardness reading increase to 66. It can be observe that when the fibre loading is higher, the modulus also increasing. This is due to the strong relationship exists between the modulus and the hardness.

There are more research regards the hardness testing. One of it is the journal from M S Sreekala et al. (2002). This journal observe a hardness test along with the density and the void information. As others, the journal also prove that when the polymer reinforcement is added, the hardness of the composite will specifically drop. It sis show that through the hardness shore D testing is affected when the fibre loading is differ.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Throughout the project, four phases are introduce in order to get an excellent result. The phases are the collecting information, project drafting, conduct experiment and analyse the data. The collecting information is a phases that the theory and the past research is studies. Most of the information about the fabrication and the testing is obtain from the information collecting phases. Next, in order to get a clear information on the testing, a visit to the lab involve is a must. From the observation, the project flow can be draft before undergo the testing. The project must be drawn to avoid any failure. For every testing, a right machine or apparatus must be used. This is to avoid from misuse the machine. Figure 3.1 shows the flow work of the project.

After the data have be fully collected, a proper experiment must be conduct depends on the testing. A good time management need to be applied during this phase in order to avoid from wasting the time. Study the factors of every test. So that, failure or accident can be avoid. For the last phases, the data that obtain from the testing need to be record. This is easier for us to compare the data with the theoretical data that obtain from the journal or the past studies. The data need to be analyse in order to find a good conclusion for the study.

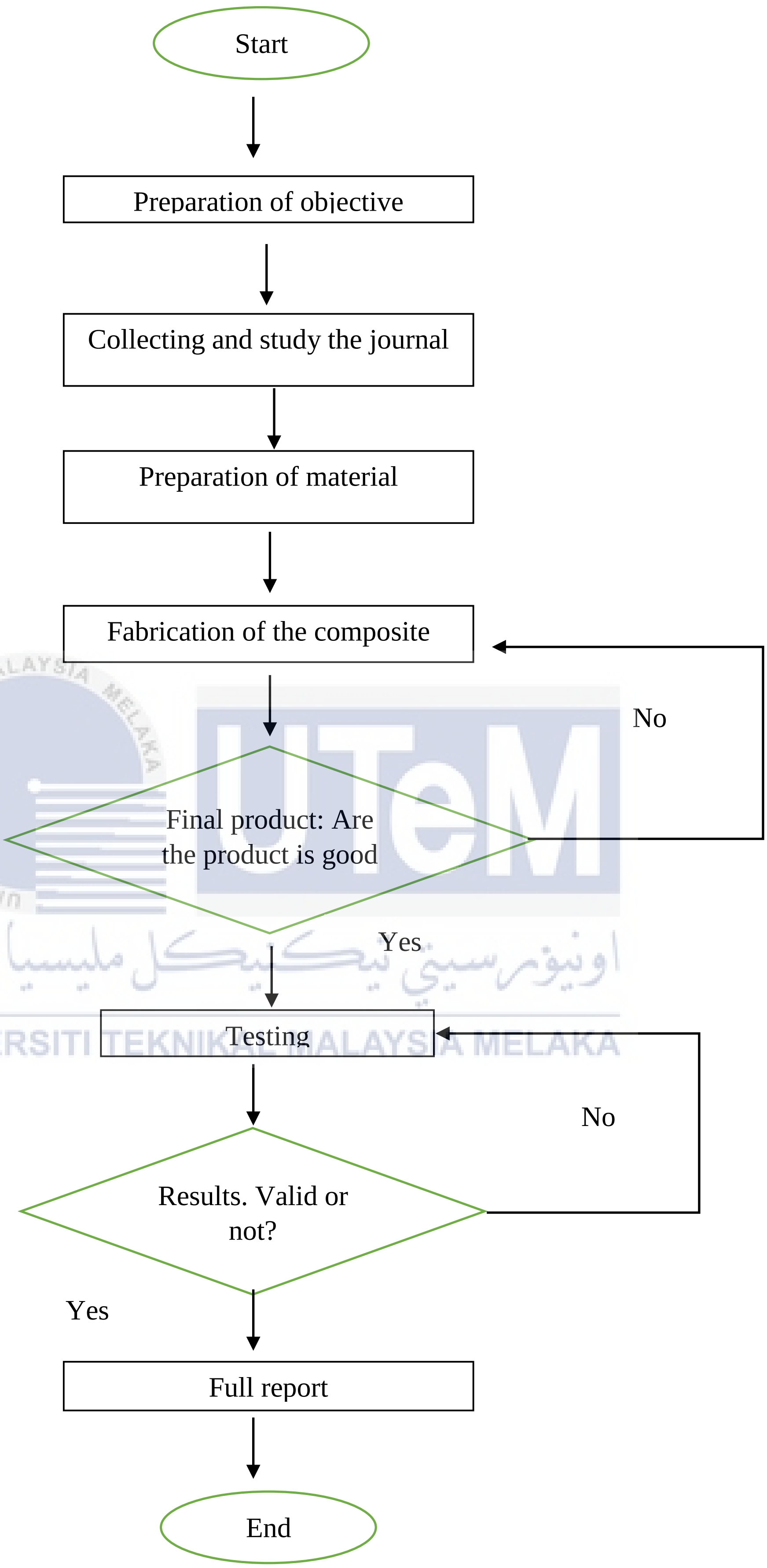


Figure 3.1 : Flow work

3.2 Research and studies

To get a complete data and information about the overall experiments, the past studies and also the journal can give a better understanding about the project. Find the journal as much as we can. The more journal refer, the more information will be gain. As a beginning, prepare the literature review is the best method in order to help us find the summary of the journal. The collected data and the information can help us in fabricate and testing process.

As a summary, the journal need to be study frequently so that many information can be obtained. More information will help in avoid problems in future. From the research and the past studies also can help in draw the specification need for every testing that will be conduct. The journal must refer to the objective that have been set in the beginning of the project. Through the research also, we may find the best apparatus and tools that can be used. This can help us from wasting the time. Last but least, meeting the supervisor also one of the method to gain information. Supervisor can help us in highlighted the important issue that need to be use in a project. They also can help us to generate idea for every issue arise.

3.3 Materials

For the project, a natural fibre and the polymer composite is used in order to produce a composite. The natural fibre used is the kenaf powder and the polypropylene (PP). Both of the materials are mixed together based on a specific proportion. According to W. H. Haniffah et al. (2015), the composite can be divided into the following proportion (Table 1.1):

Percentage Weightage	
Kenaf	Polypropylene (PP)
20	80
30	70
40	60
50	50

3.3.1 Kenaf and Polypropylene (PP)

Instead of the kenaf fibre, kenaf powder is used for the fabrication. It fabricate along with the polypropylene (PP). Both of the materials will be mixed together during the fabrication process and produce a composite. According to the R.M Rowell et al (1999), previously most of the industry produce a product combination of natural fibre and thermoplastic. However, the thermoplastic cost more over the past years. Due to that the combination of natural fibre and the polymer is applied.

For the experiment, the Kenaf powder was obtained from a KF manufacturing company located in Semenyih. However, the primary source of the Kenaf powder is from MARDI, Selangor. Initially, from the bacteria retting process, the kenaf fibre were extract from the bast (Hafizah *et al.* 2014). The kenaf powder will be used for the fabrication to make it easier. According to NK Kamardin (2014) , the limitation of the Kenaf powder size is 100μm. below are the Kenaf powder that will be used for the fabrication process. The figure 8 show the Kenaf powder that has been supplied.

Figure 3.2 : Kenaf powder

Polypropylene can be used to mix with any kind of natural fibre. However polypropylene (PP) is the most suitable polymer that can be used together with the Kenaf powder. From C.H. Lee (2017) study stated that kenaf/PP composite is the best composite compare to other natural fibre because the cellulose content and the orientation of micro fibrils in a great manner. For the experiment, the PP was obtained from the home university (UTeM) . The Polypropylene that will be used for the fabrication is in the granules form. From the past research paper, most of it use different type of polypropylene that comes with different sizes.

But, the disadvantage of the mixture composite is the thermal degradation temperature will be reduce. Due to the reduction, the thermal stability of kenaf will be lower than polypropylene (C.H. Lee *et al*. 2017). According to the N I S Anuar et al (2017) journal, stated that the interfacial bonding between the fibre and the polypropylene is the crucial factor that effect the mechanical properties.

Figure 3.3 : Polypropylene polymer

3.4 Composite Preparations

For the composite preparation a few procedure need to be follow. There are three major process need to be done to completing produce the composite for the testing. A lab visit in Faculty of Manufacturing is conduct in order to observe the machine that will be used for the composite fabrication. To fabricate the composite, the three major step need to be follow.

3.4.1 Internal mixer

The first basic step need to be process is to mixed both material which is the kenaf fibre and the polypropylene (PP). The internal mixer is made up by a few parts such as the ramp, filler, rotor, heaters, thermocouple and the power supply. The limitation for the process is limited to maximum 50 gram mass only for both materials. In the internal mixer, the proportion of the material will be set as mentioned previously. The first process for the fabrication is to mix both material. For each proportion at least need 500g of the composite. The internal mixer can only withstand for 50g per time. In order to get the 500g of the composite, the process for each proportion need to be repeated for ten times. The process need to be observe in order to avoid the kenaf powder from burnt. The gap duration between the PP and the kenaf powder to be pour into the internal mixer also need to be observe. It is to make sure the composite are mixed well. For each process, only 8 minutes needed to make sure the materials mixed well. Figure 3.4 show the product of the composite result internal mixer process. While the figure 3.5 is the cross sectional area of internal mixer.

Figure 3.4 : Composite product

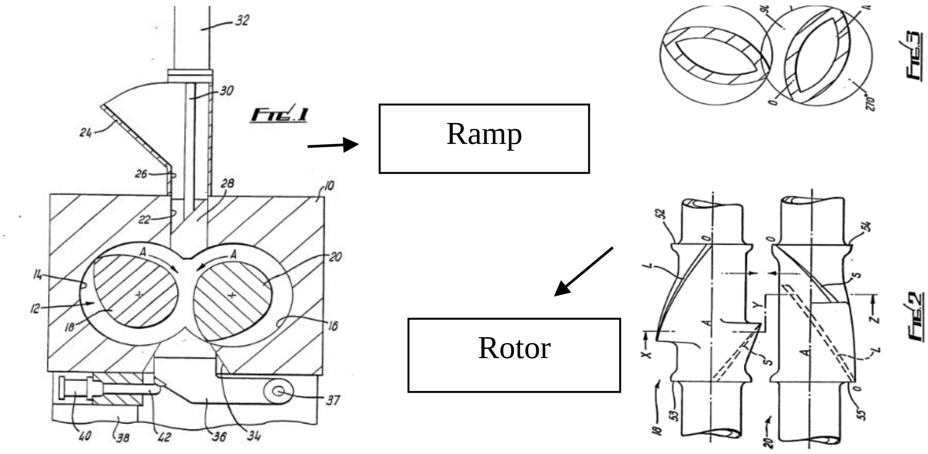


Figure 3.5 :Schematic diagram of Internal Mixer (resource google)

3.4.2 Crusher machine

After the process in the internal mixer is done, let the composite product cooling for a moment for a few minutes. Then, the composite will be undergo the crushing process using the crusher machine. The crusher machine function to make the size of the composite reduce from the initial. A smaller size of composite is needed in order to make the fabricate process easier. The composite from the internal mixer give a big size material. By using crusher machine, the size will be reduce and it produce a composite in a granule size. There are no limitation towards the mass. The amount of material that can be crush are not specified. The composite can be crush at a huge amount for one time.

To do this process, the first step is to on the power machine and running the motor. The safety equipment must be wear to avoid any accidents. Next, the composite material is put into the crusher machine. The material is let to crush for a minute. After done, the machine must be switch off. Then only, we can take the crush material at the bottom. Lastly, the crushing area need to be clean up after the process. Figure 3.6 is the schematic diagram of the crusher. While figure 3.7 and 3.8, is the result of the specimen after the crushing process.

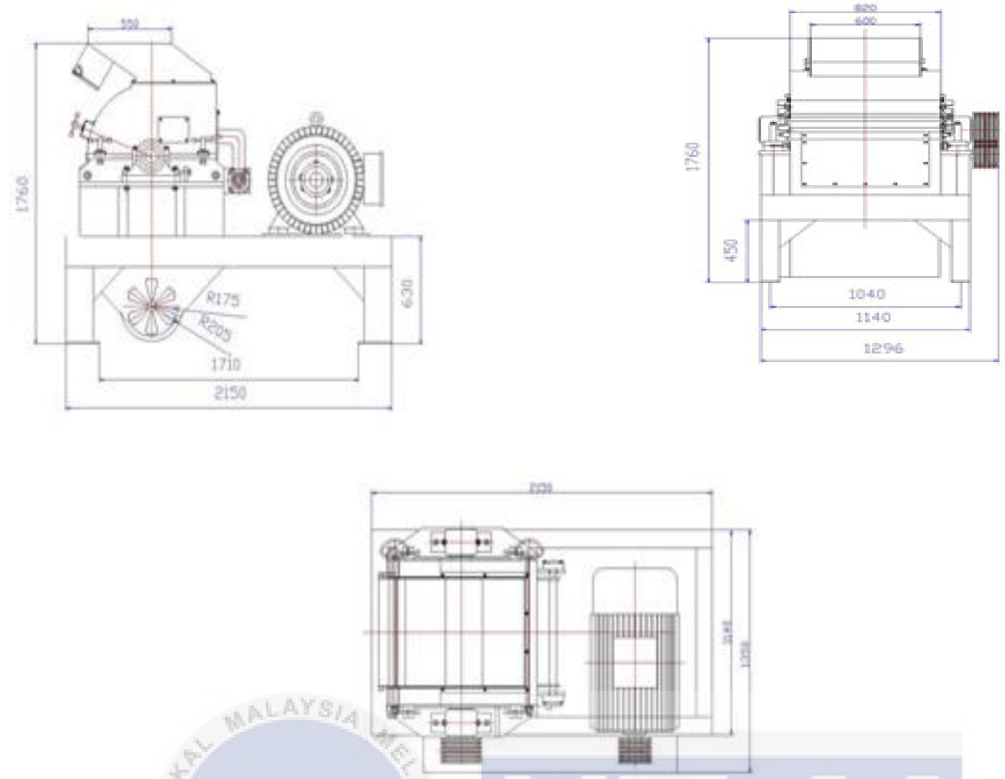


Figure 3.6 : The crusher machine schematic diagram (resource :simecplant)

Figure 3.7 : The crushing process

Figure 3.8 **:** The granule size of the composite

3.4.3 Hot – press machine

For the compression process, hot press machine is used. The parameter such as temperature, duration and pressure is differ by different mold. For different testing, different mold is used. For the hardness, the specimen size is 6.5x5x0.3 cm while water absorption test, the size of the specimen needed is 4x5x0.3 cm. However, to make it easier, the 20x10x0.3 cm mold is used and will be cut into three and five respectively. For the process, 10 minutes is needed for compression and cooling process by using 180°C. Figure 3.9, is the mold that be used for specimen using in the water absorption and hardness testing.

Figure 3.9 : 20x10x0.3 cm mold

While for the heat conduction testing, different mold is used. Cylinder mold of diameter 30 mm is used to make sure it fit with the infrared lamp equipment. The time needed to make a product is for 25 minutes with 210°C.

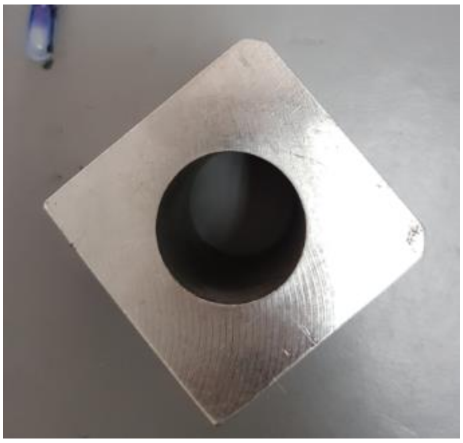


Figure 3.10 : cylinder mold

However, there are some error occurred when using the mold. At the inner part of the composite, there are blank space due to the air bubble trap during compression process. Due to that, we modify the mold by make 4 hole for each side

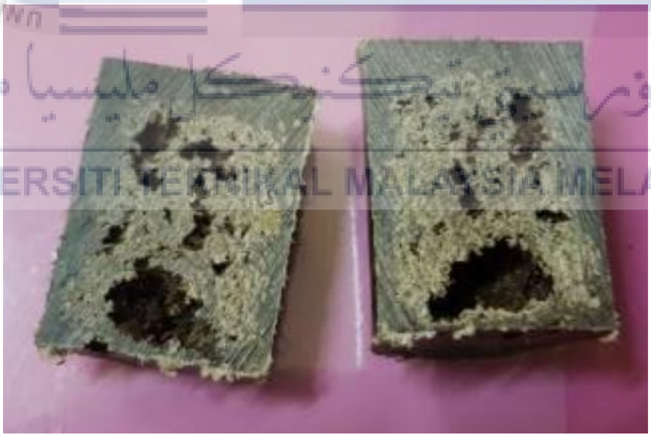


Figure 3.11 : The air bubble trap effect

Figure 3.12 : The hole on the mold

Next, the size of the closure of the mold is reduce after the hot press process. Due to that, two washer is needed for the top and the bottom of the mold. The washer is made by using the CNC plasma machine as in figure 3.13. The cross sectional areas of hot press can be seen form figure 3.14.

Figure 3.13 : Mycut CNC plasma

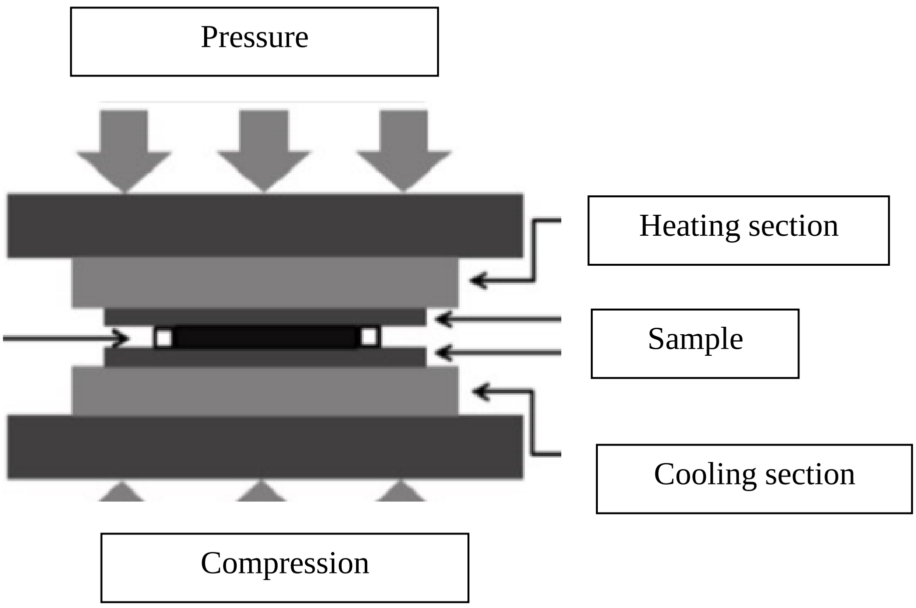


Figure 3.14 : The hot-press machine (resource :researchgate.net)

3.4.4 Product

After all process is completed, the composite product is produce. There will be 20 specimen for the hardness test and heat conduction test respectively, 20 specimen for the water absorption test. Figure 3.15 is the product for the hardness and the water absorption test before cutting into the desired shape. While figure 3.16 is the product for the heat conduction test.

Figure 3.15 : The 20x10x0.3 cm product

Figure 3.16 :The cylinder product

3.5 Thermal Conductivity Test

The testing that is conducted to know the thermal properties is the thermal conductivity testing. As its function itself that need to control the heat transfer, this testing is important in order to find the suitable thermal conductivity value for the thermal insulator.

This testing is not related to any ASTDM. The preparation of the testing is very simple. As long the power source is available, the testing can be conduct. The machine that been use for this testing is the Panasonic infrared lamp and the infrared thermometer gun.

The machine is use to find the temperature different on the top and bottom surface of the kenaf composite. A square polystyrene board with a hole at the centre is positioned 0.3m from the light source. The sample is put in the polystyrene board. The function of the board is to avoid the heat transfer on every side. This is because for this testing, only axial direction of heat transfer is needed. Then, the infrared light source is dispersed on the surface of the kenaf composite. It dispersed 150 W power to the composite surface. The data is recorded in interval time of 2 minutes. The data is stop recorded when the temperature of both surface is constant. Next, by using the infrared thermometer, shoot to the centre of the kenaf composite surface and the temperature reading will be appear on the infrared thermometer gun. The changes of the temperature will be calculated. The value of the thermal conductivity can be obtained by applying it into the equation 1.

Equation 1 : $$k = \frac{QL}{A\Delta T}$$

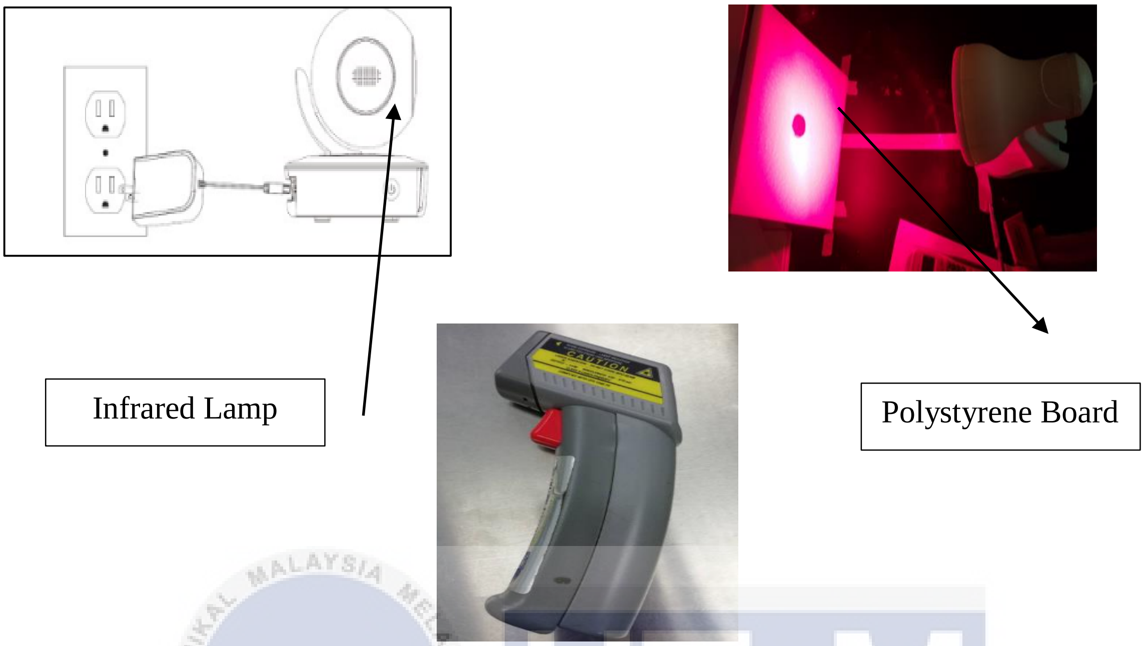


Figure 3.17: The setup of the Infrared lamp and thermometer gun

3.6 Water Absorption Test

Figure 3.18 : Water Absorption testing

For the water absorption, the test will determine the amount of water intake of the composite after immersion into the liquid. The testing are obey the ASTM D 570 in order to get a proper result. There are 20 sample that will be used for this experiment. The size of the specimen is 4x6x0.3 cm. The first process is to put the sample into the dry oven for 10 minutes. Then, the sample is divide into 4 beakers based on the fibre ratio. There are 5 sample for each beakers. The data is recorded in 24 hours interval time for 7 days. Finally, the percentage of the moisture can be recorded. Based on Z Salleh et al (2012), stated that the percentage of the water uptake can be obtain by using the equation as follow :

Equation 2 : $$w\ (\%) = \frac{Wi - Wf}{Wi} \times 100\%$$

$\mathbf{W}_i$= The weight of the specimen before immersion

$\mathbf{W}_f$= The weight of the specimen after immersion

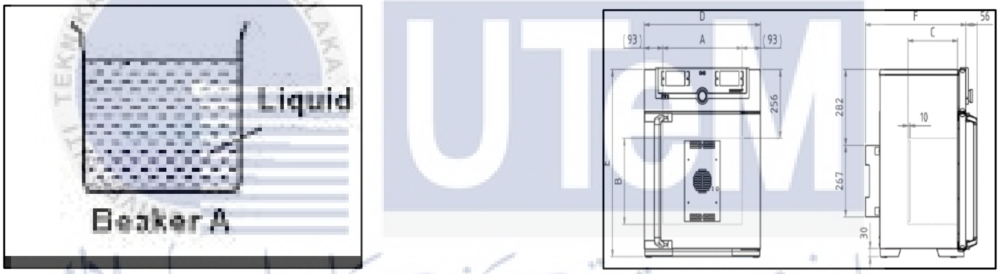


Figure 3.19 : Schematic diagram of beakers and dry oven (source google)

3.7 The Hardness Testing

Figure 3.20 : Hardness durometer testing

For the hardness testing on the kenaf/pp composite, the shore D durometer is used. The shore durometer function to investigate the hardness of the fibre and polymer composites. The shore D durometer can be find in the lab at Faculty of Mechanical Engineering.

The durometer is normally used to measure a soft materials. Kenaf/pp composite is one of the material that can be used for the durometer hardness test. The durometer consists of a few part such as the pressure foot, the indentor and the indicating device. The schematic diagram are show in the figure 3.21 below. The specification of this experiment is obey the ASTMD 2240.

The durometer is used because it is the easier method to know the hardness of kenaf/pp composite. The experiment start by choose a proper durometer for the testing. For this experiment type D is choose. Then, the specimen is put on a hard and flat surface. Next, the durometer is hold. The indenter of the presser foot must away of 12mm from the specimen edge. The presser foot then is press on the specimen without any vibration occur.The position of the specimen must parallel to the surface of the test block. The pressure apply must be enough to let the pressure foot fully contact with the specimen. Within 1 second after the presser foot and the specimen are fully contact, the reading must be taken. The hardness of the specimen is measure for 2 times each at a different location on the specimen. Then, the whole process is repeated for different proportion of kenaf/pp composite. For this testing only 5 sample is needed for a perfect result.

However, during the testing, a few precaution need to be highlighted in order to avoid errors from occur. Such as the hardness reading is taken at least three point. Before the test, the pointer of the durometer need to be check. Make sure it is a Free State point to zero. The specimen should not less than 6x15x25 mm in dimension. The temperature must be fixed to one temperature which is the ambient temperature (23ºC).

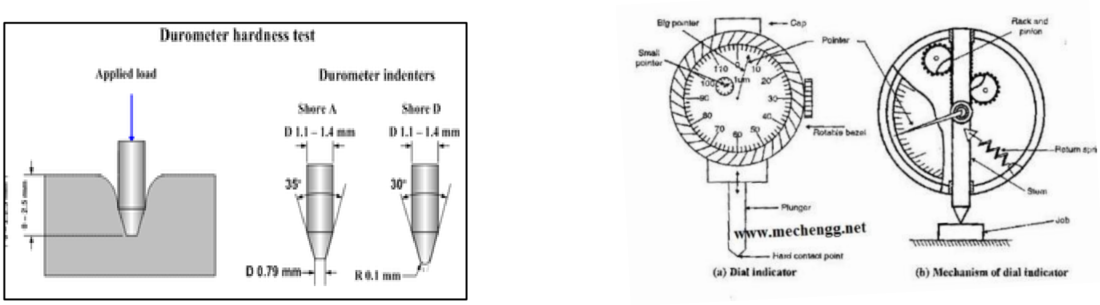


Figure 3.21 :Schematic Diagram Hardness shore D (source google)

CHAPTER 4

RESULTS AND DISCUSSION

4 RESULTS

The result of the study is obtained after the fabrication and the three testing is completed. It took for almost two month in order to complete the fabrication process and the testing.

4.1.The thermal conductivity test

From the test, the k value of the composite can be determined by substitute it into the equation. Previous journal by Darshil Shah et al. (2015) stated that the thermal conductivity (k value) is related to the density of the composite. The journal prove that at high density the thermal conductivity value is at low. It is also stated that the k value for the natural fibre are between 0.5 to 0.7 W/m.K. However, in these cases, the density of the specimen is constant. New parameter is study in order to find the best thermal conductivity value.

The sample size use for the testing is 31mm with thickness of 25mm.

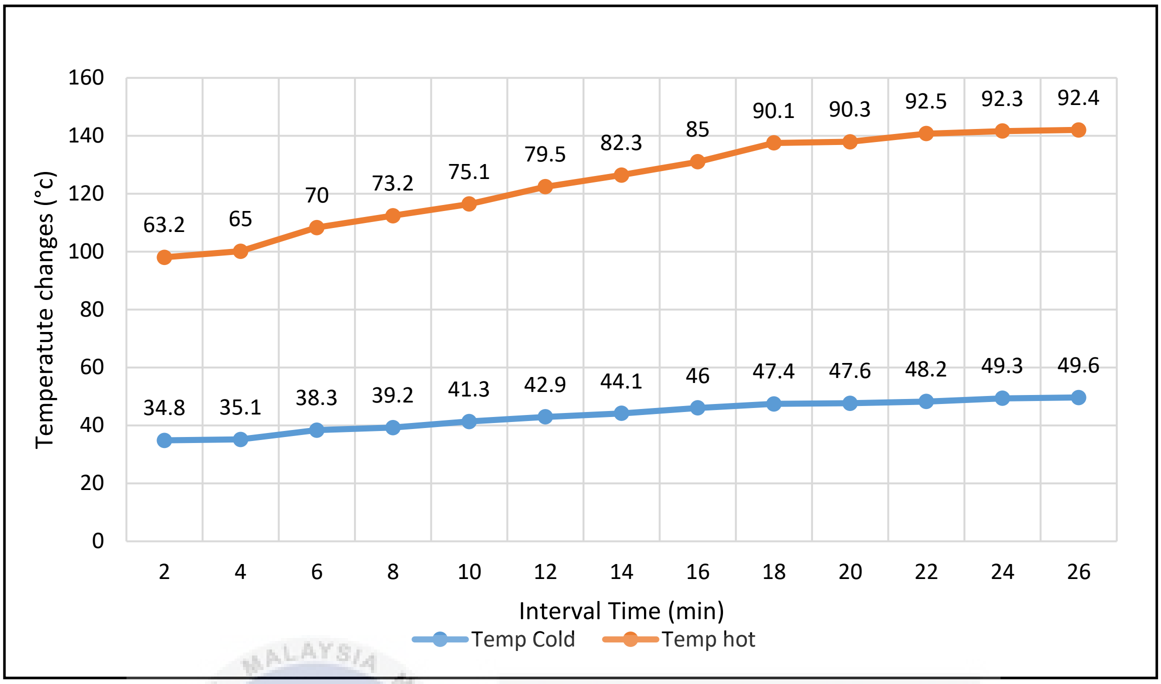


Figure 4.1 : temperature changes on fibre ratio 50:50

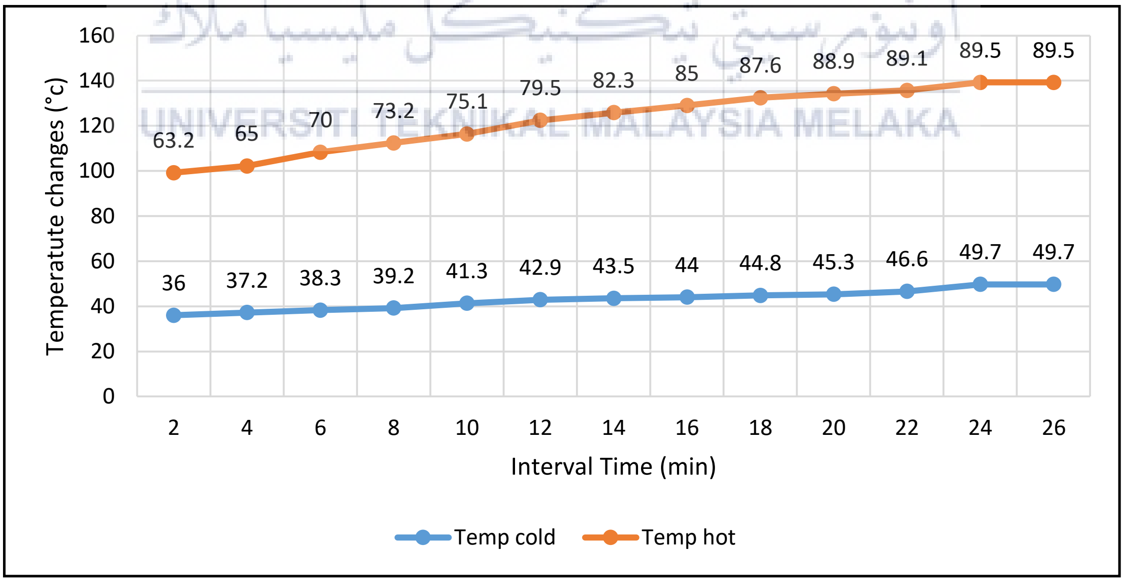


Figure 4.2 : Temperature changes on fibre ratio 60:40

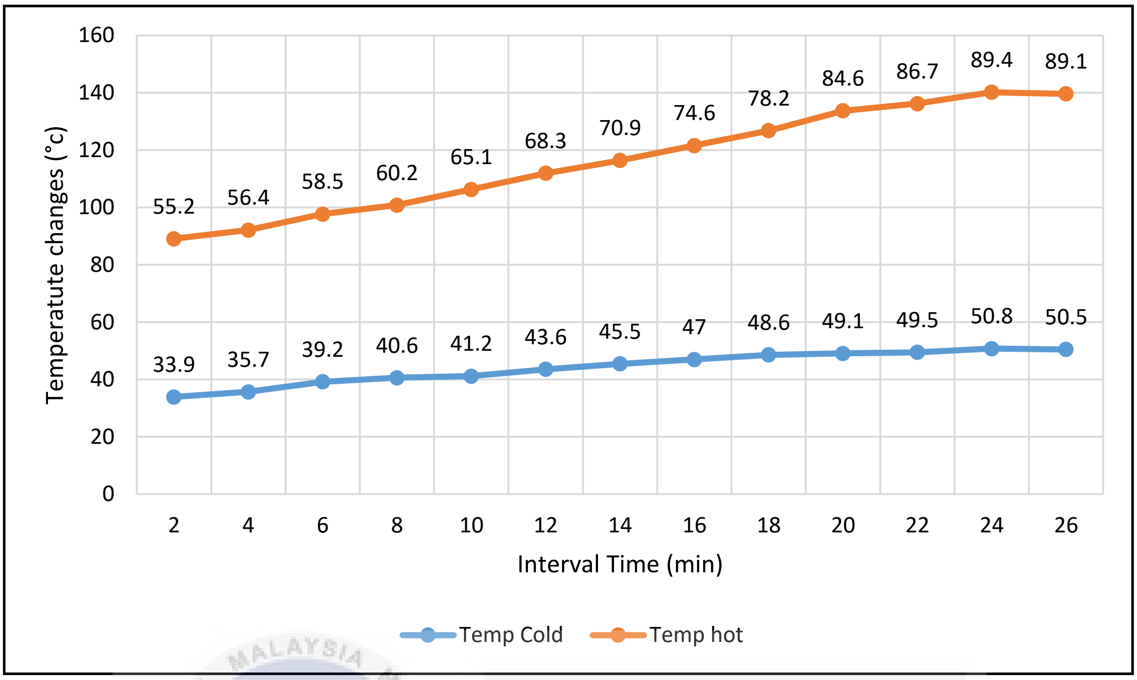


Figure 4.3 : Temperature changes on fibre ratio 70:30

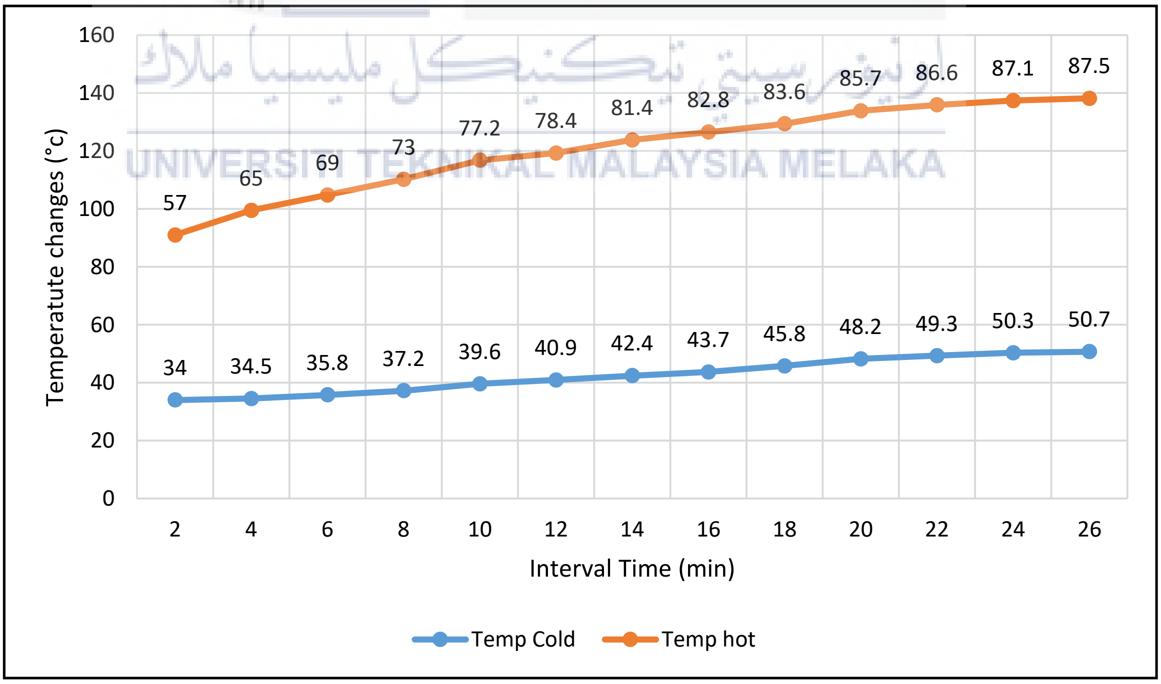


Figure 4.4 : Temperature changes on fibre ratio 80:20

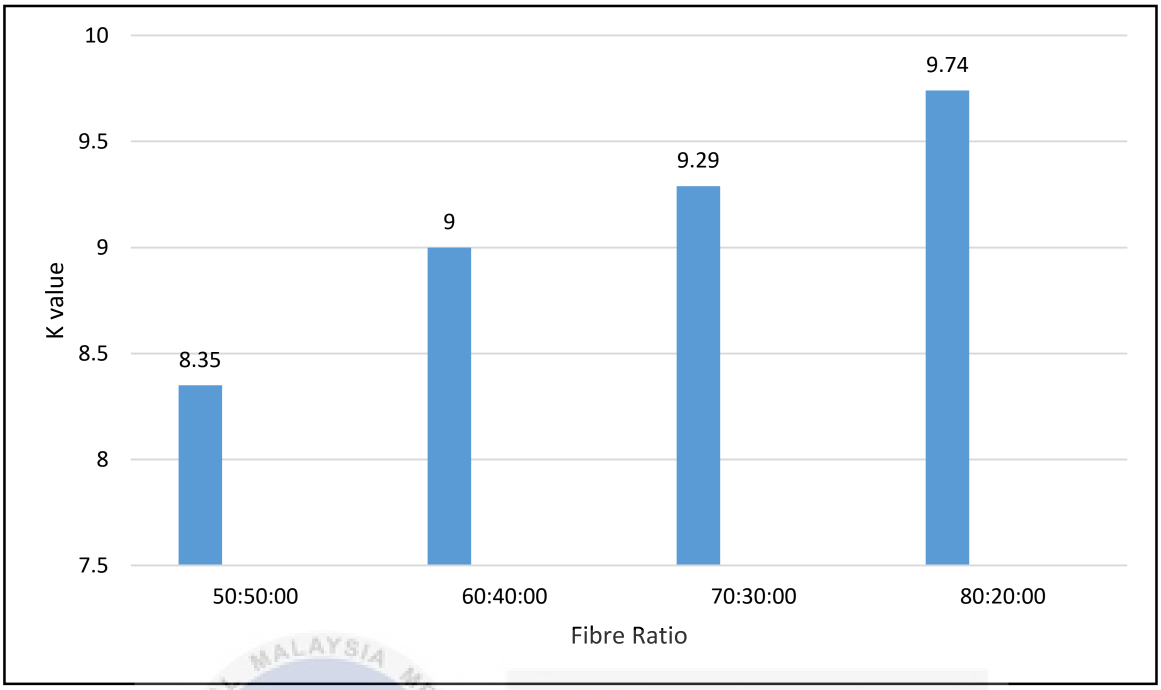


Figure 4.5: Relationship on thermal conductivity

Conducted in the constant temperature room of 27°C makes the experiment data obtain is valid. Mention in one of the journal from Darshil et al, the main factors that can changes the performance of the thermal conductivity are the thickness, density, temperature and the fibre ratio. But, as mention the density in the experiment is fixed for 0.91 g/ms^2. Due to that, the high probability factors that can influenced the value of the thermal conductivity is the temperature and the fibre ratio. In order to get the best result for the thermal insulation, the value of thermal conductivity must be low.

Suggested in the B P Jelle et al journal, many kinds of thermal insulation method has been suggested such as the Vacuum Insulation panels (VIP) and Gas filled panel (GFP). These both method is studies because they can improve the performance of the thermal insulation. A low value of thermal conductivity is required in order to be establish as good thermal insulator. That is the findings of the journal.

The same objective is apply in the experiment on different value of fibre ratio. In every fibre ratio data in figure 4.1 until 4.4, the temperature for both surface is recorded. For top surface, the temperature range is between 55. 2 to 92.4°c. While for the bottom surface range between 33.9 to 50.7 °c. The data is recorded after the readings of the temperature is constant. It took about 26 minutes for each ratio in order to get a good data. However, the data may not be valid as the previous journal because the surrounding temperature cannot be fixed to 25°c throughout the experiment. So, the thermal conductivity value of the experiment may differ from the journal. The figure 4.5 explained the effect on the changes of the fibre ratio on the k value. The changes resulted to the drastic changes in the k value. This is actually the aim of our study which is to find the best ratio for the low thermal conductivity value.

Evidence for the changes of fibre ratio is borne out by S W Kim et al's journal that prove when the coupling agents of MAPP is added together with the polypropylene, the ratio of fibre is decrease and cause the k value to increase. This is because the factors that influencing the thermal conductivity value. The major factor is the purity of the materials. Thermal conductivity of pure material is higher than composite. On these ground, can be show that, the instability of the ratio on polypropylene and kenaf powder cause the k value to increase when the fibre ratio is decreasing. M Idicula et al has encouraged debate on the effect of the fibre ratio. The effective of the thermal conductivity depends on the individual material conductivity. From the journal recorded that the k value decrease from 0.181w/mK to 0.153 W/mK and 0.140 W/mK when the fibre ratio of 0.20 and 0.40 is added to the polyester respectively. So, it is proven that the addition of the fibre leads to the decreasing value of the k value. From the journal also inform that, the decreasing of k value of the composite due to the incorporation of the natural fibre. The resin matrix is a priority compare to the kenaf.

To achieve the objective of the project, the lowest k value need to be choose in order to fulfil the thermal insulation properties. This is because the thermal conductivity is inversely proportional to the thermal insulation. There seems to be no compelling reason to argue that the composite with fibre ratio of 50:50 is the best material to act as a thermal insulator. This is because this ratio has the lowest value of the thermal conductivity.

4.2 The Water Absorption test

As mention the water absorption test is follow the ASTMD 570 and ASTMD 5229. So, the result from the previous research is used to predict our result. Based on Z Salleh et al (2012), stated that the percentage of the water uptake can be obtain by using the equation 2.

For the water absorption testing, five specimen from each fibre ratio is tested to get an accurate result. The testing is conduct in the composite lab for seven days. The result is recorded after and before the immersion of the specimen. This is to observe the difference before and after the immersion. From the data, the analysis on the moisture content can be made. Below are the experimental data that obtained from the testing. The data is tabulate in the table below by different fibre ratio.

Table 4.1 : Composite composition of 50:50

Hours	Weight changes (g)						Moisture Content (%)
	1	**2**	**3**	**4**	**5**	**Average**	
24	0.51	0.50	0.51	0.52	0.51	0.51	8.50
48	0.68	0.69	0.69	0.69	0.67	0.69	9.58
72	0.82	0.82	0.83	0.83	0.83	0.83	11.52
96	0.92	0.92	0.92	0.92	0.92	0.92	11.46
120	1.03	1.04	1.04	1.04	1.04	1.04	11.60
144	1.10	1.09	1.11	1.12	1.10	1.10	11.01
168	1.15	1.15	1.14	1.15	1.15	1.15	10.37

Table 4.2 : Composite composition of 60:40

Hours	Weight changes (g)						Moisture Content (%)
	1	**2**	**3**	**4**	**5**	**Average**	
24	0.47	0.47	0.48	0.48	0.49	0.48	8.00
48	0.55	0.55	0.55	0.53	0.55	0.55	8.48
72	0.69	0.69	0.72	0.71	0.70	0.70	9.96
96	0.98	0.98	0.98	0.98	0.98	0.98	12.67
120	1.01	1.01	1.00	1.00	1.00	1.00	11.48
144	1.09	1.10	1.10	1.10	1.10	1.10	11.33
168	1.12	1.12	1.13	1.10	1.12	1.12	10.36

Table 4.3 : Composite composition of 70:30

Hours	Weight changes (g)						Moisture Content (%)
	1	**2**	**3**	**4**	**5**	**Average**	
24	0.35	0.35	0.35	0.37	0.37	0.36	6.00
48	0.44	0.45	0.44	0.44	0.44	0.44	6.92
72	0.58	0.56	0.59	0.58	0.58	0.58	8.53
96	0.63	0.62	0.62	0.64	0.63	0.63	8.54
120	0.76	0.76	0.76	0.76	0.76	0.76	9.49
144	0.97	0.97	0.99	0.97	0.97	0.97	11.06
168	0.99	0.99	1.00	1.00	1.01	1.00	10.26

Table 4.4:Composite composition 80:20

Hours	Weight changes (g)						Moisture Content (%)
	1	**2**	**3**	**4**	**5**	**Average**	
24	0.18	0.19	0.19	0.18	0.18	0.18	3.00
48	0.28	0.30	0.27	0.27	0.27	0.27	4.37
72	0.33	0.33	0.33	0.32	0.32	0.33	5.12
96	0.48	0.47	0.48	0.48	0.48	0.48	7.08
120	0.60	0.60	0.62	0.63	0.60	0.61	8.40
144	0.77	0.78	0.77	0.77	0.77	0.77	9.78
168	0.87	0.88	0.88	0.87	0.87	0.87	10.07

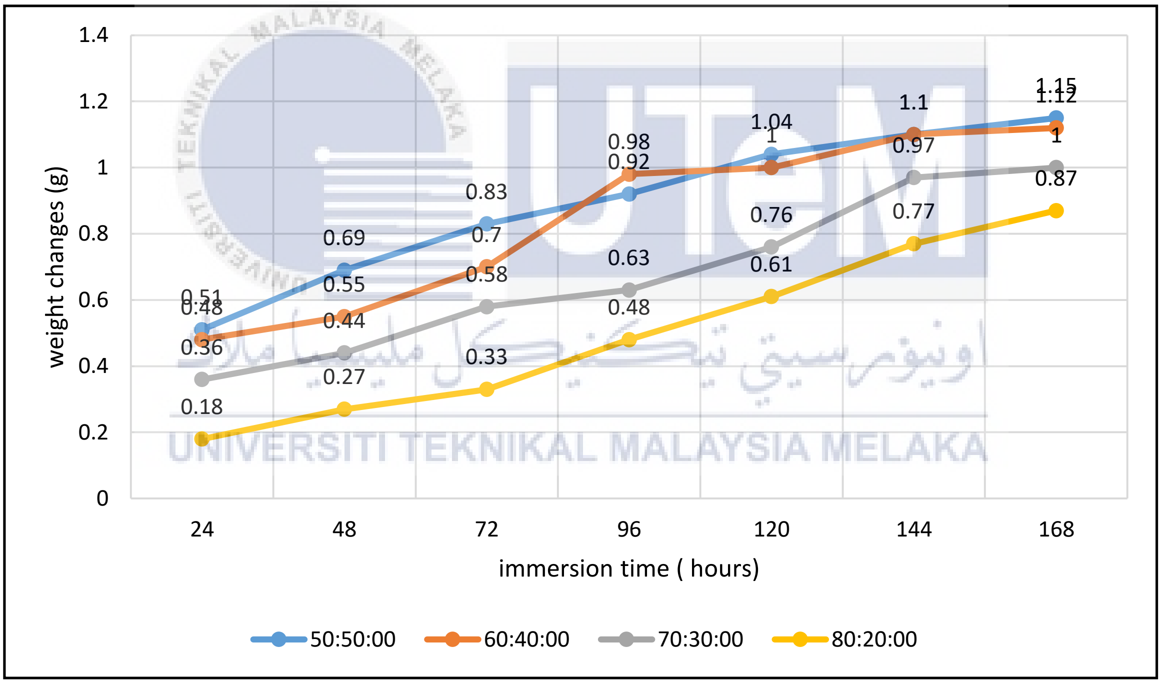


Figure 4.6 : Relationship between immersion time and weight changes

There are few properties need to be highlighted in choosing the kenaf composite as the thermal insulator. The water absorption testing is an indicator in order to know the effect of the moisture properties on a kenaf composite. Water absorption is a crucial properties that need to be consider especially when involved the outdoor application. Especially for the installation at houses that comes with wet kitchen and bathroom. The moisture factors is an issue because the behaviour of the kenaf composite can be affected when the fibre ratio is changes.

From the experimental data in the table above, can be stated that, the immersion time of the composite affected the weight changes of the kenaf composite. The highest weight changes is at the fibre ratio 50:50. After 168 hours of immersion, the kenaf with 50:50 ratio give 1.15 g of changes in mass compare to the lowest weight changes of 80:20 ratio. This phenomena can be explained by the properties of the kenaf. When kenaf is exposed to the moisture or humid environment, it will be swelling. The condition become worse due to the hydrophilic characteristic of the kenaf composite that cause the water to be penetrate more. Reported by Nosbi et al, the swelling of kenaf will lead to the micro cracking and failure.

In the present study, the issue under the scrutiny is mention by the M Ramesh's journal in the water absorption parts. He stated that the characteristic of the water absorption is influenced by a few factors such as the fibre content, the fibre orientation, and the area of exposed, temperature and the status of hydrophilicity of the material. In this issue of matter, only fibre content and the status of hydrophilic properties will be study.

On the logical grounds, there is no compelling reason to argue that the time immersion of the composite give a huge impact on the moisture content. This is because logically when the immersion time is increasing, the changes in mass also will increase. There is growing support for the statement from A Ladhari et al that stated the changes in mass is directly proportional to the immersion time. Along similar lines, the journal of Z Salleh et al also highlighted that the immersion time will give effect on the moisture content.

Z Salleh develops the claim that even though the moisture content is increasing with the immersion but the percentage of the moisture content is not stable. It is fluctuated as in table 4.1,4.2,4.3 and 4.4. The data recorded from the journal is always changes in moisture content from 4.41%, 4.86%, 8.60%, 9.99% and 7.35% when the immersion time is changes up to week 4. However, the trend of the data is still increase.

Figure 4.7 shows the relationship between the fibre ratio and the moisture content that used to be explained in the Norlin Nosbi et al journal. In the journal is focus on the different type of liquid immersion. To compare with the data only the distilled water data is valid.

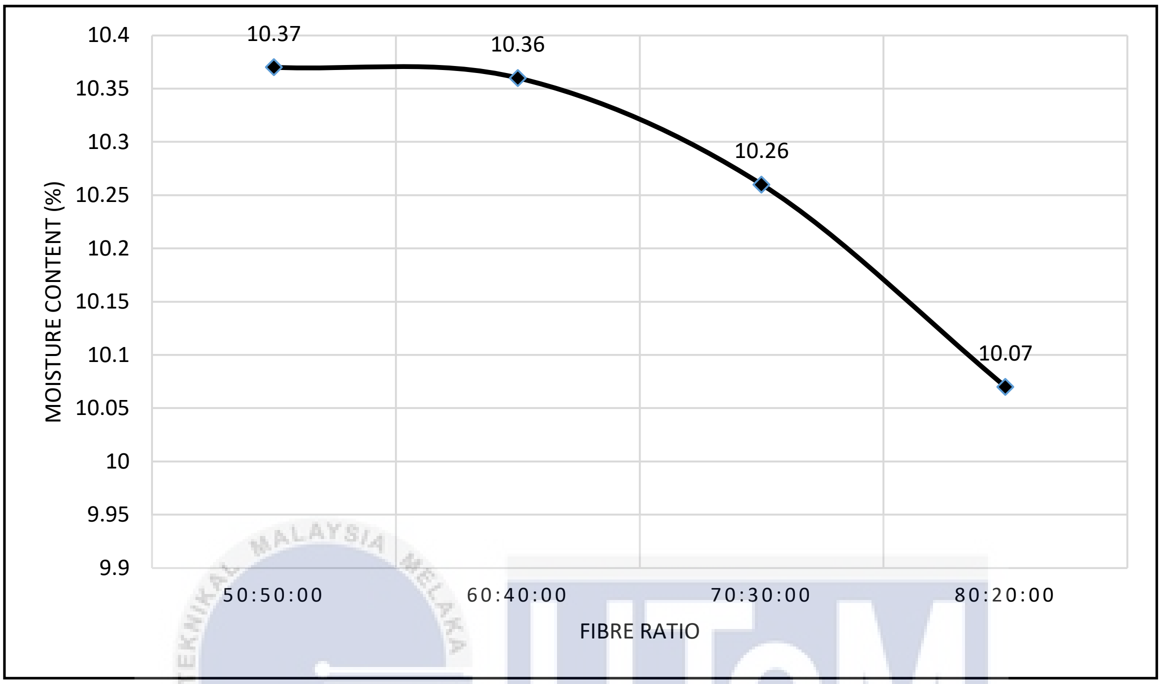


Figure 4.7 : The graph of moisture content of different fibre ratio

From the figure 4.7 can be analyse that the fibre ratio is increasing linearly to the percentage of the moisture content. Based on Nosbi et al, this is because of the presence of the hydrophilic characteristic of the kenaf itself. Daly et al also proved that the moisture is influence by the status of hydrophobic behaviour of polypropylene and the hydrophilic behaviour of the kenaf powder. The hydrophilic of fibre and the hydrophobic of matrix cause the fibre to swelling. M M Kabir et al findings lends support to the claim that the hydrogen bond breaks and the hydroxyl group will form another hydrogen bond with the liquid particles. This is encourage the liquid penetrate more into the structure. The foregoing discussion implies that the experiment data in figure 4.7 is same with the previous journal that has been studied. The increasing in the hydrophobic behaviour of kenaf lead to higher moisture content.

The thermal insulator of kenaf composite may be install as a wall and ceiling. The condition of the surrounding may be differ on every area of installation. Especially the bathroom and kitchen. In these two are, surely the percentage of the moisture content is high.

So, the available evidence seems to suggest that, a low fibre ratio can act as a good thermal insulator in terms of moisture environment. This is because the low fibre ratio will leads to low percentage of moisture content. It can fulfil the properties of a good thermal insulator.

4.3.Hardness testing

The data of the hardness on the composite is observed in order to know the performance of the composite as a thermal insulator. In order to be a good insulator, the hardness need to be tested in order to make sure the composite can withstand with any extreme condition. The test is conduct in order to know the relationship of the hardness and the fire resistance. Besides, the hardness properties also can help in choosing the best kenaf composite in terms of building adaptation and the durability. In order to choose a good thermal insulator, the safety issue need to be highlighted. It is because the thermal insulator will be install in the building.

Table 4.5 : Fibre ratio 50:50

Specimen / Point	Hardness			
	1	2	3	Average
1	40	41	39	40.00
2	40	40	42	40.67
3	41	41	42	41.33
4	38	41	39	39.33
5	40	42	44	42.00
Average				40.67

Table 4.6: Fibre ratio 60:40

Specimen / Point	Hardness			
	1	2	3	Average
1	52	51	52	51.67
2	53	55	50	52.67
3	50	51	48	49.67
4	55	50	51	52.00
5	50	50	49	49.67
Average				51.00

Table 4.7: Fibre ratio 70:30

Specimen / Point	Hardness			
	1	2	3	Average
1	60	60	59	59.67
2	60	59	61	60.00
3	62	60	60	60.67
4	60	59	58	59.00
5	61	61	59	60.33
Average				69.93

Table 4.8 :Fibre ratio 80:20

Specimen / Point	Hardness			
	1	2	3	Average
1	70	71	74	71.67
2	75	72	70	72.33
3	69	73	71	71.00
4	70	72	70	70.67
5	71	71	70	70.67
Average				71.27

Stated in Bjorn Peter Jelle , 2011 journal that aside of the thermal conductivity that need to be reduce in order to choose the best thermal insulator, the adaptation, fire protection and durability of the material is also a concern. Due to that, the hardness testing is conduct to find out the best fibre ratio that can trigger the best properties. In this paper, the discussion centres on the relationship of the hardness and the fibre ratio. The available evidence seems to suggest that at each point of inspection on the sample gives difference value of hardness. It is due to the pressure apply is not persistent along the testing. Three point is set in order to average the value of the hardness of each fibre ratio.

The data appears to suggest that the fibre ratio of 50:50 give the lowest hardness among the four classes. While fibre ratio of 80:20 gives the highest value which is 71.27. Each of the data can be classify into different classes based on the shore hardness scales in figure 4.8. A closer look at the data indicates that the hardness increase from 40.67, 51.00, 69.93 and 71.27 for fibre ratio 50:50, 60:40, 70:30; 80:20 respectively. On the basis of the evidence currently available, it seems fair to suggest that the kenaf composite that have the ratio of 50:50 is scales on the hard material class. Same goes to the fibre ratio of 60:40 that also classify in the hard material class. Not to mention the fibre ratio of 70:30 and 80:20 are classes in the extra hard material class. As has been noted, can be observe that the fibre ratio is inversely proportional to the hardness strength. From the scales itself, the kenaf composite are harder if only the fibre ratio is decline.

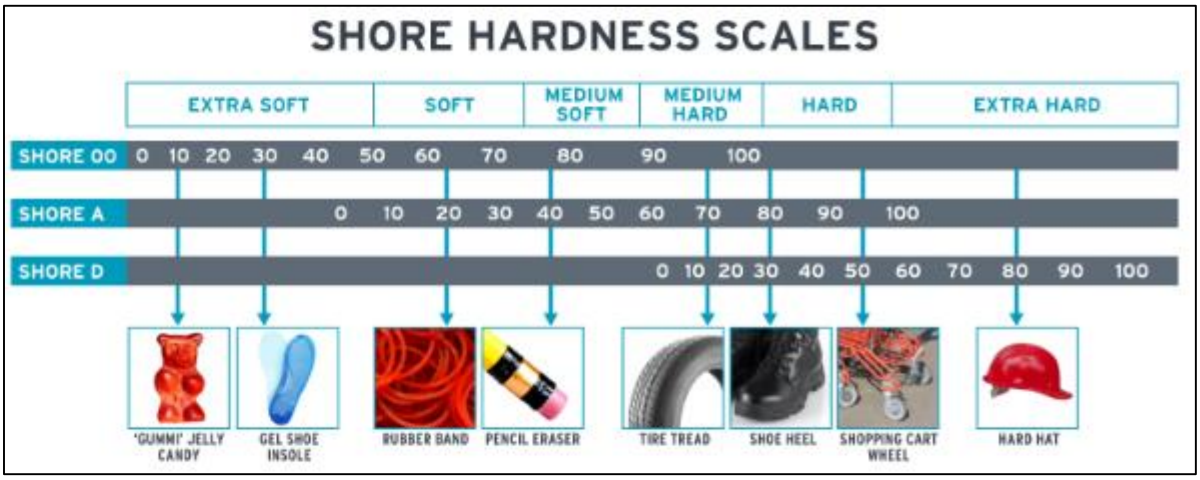


Figure 4.8: Shore Hardness Scale

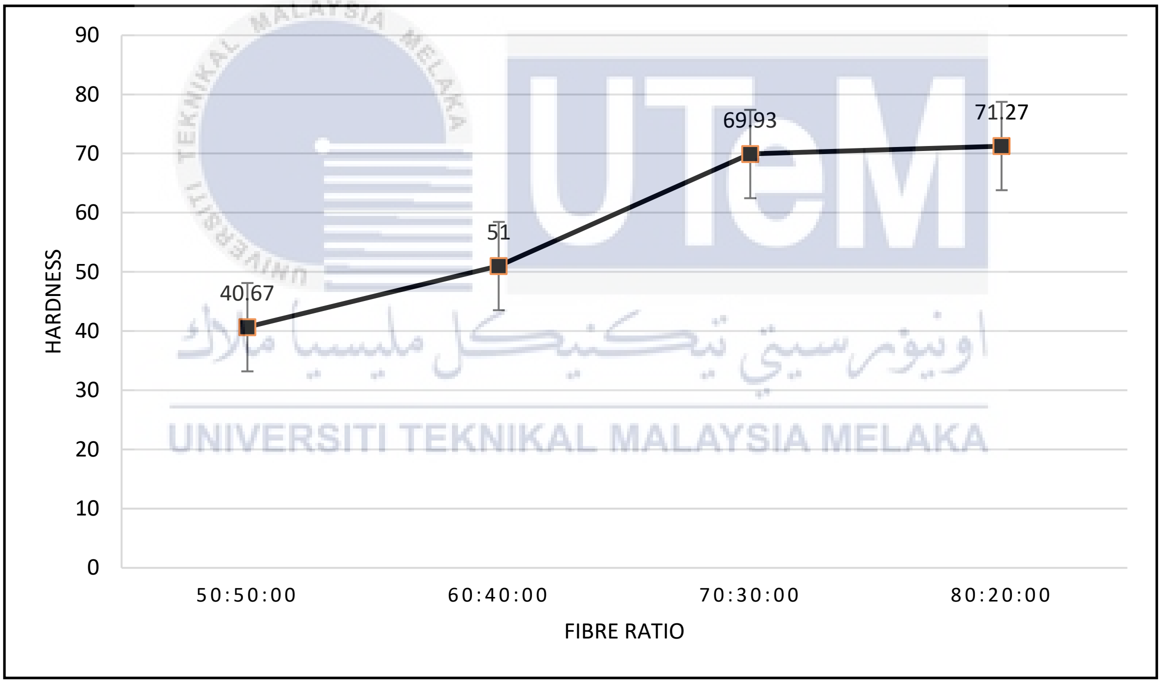


Figure 4.9 : Hardness strength of Kenaf composite

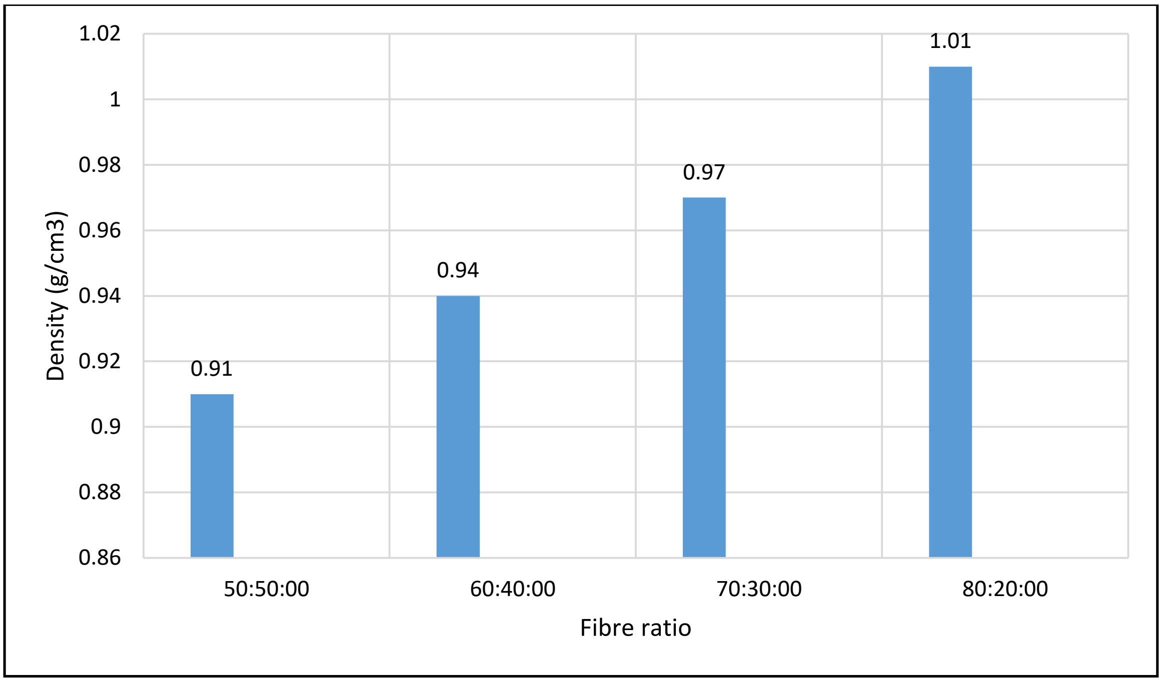


Figure 4.10: Relationship on density and fibre ratio

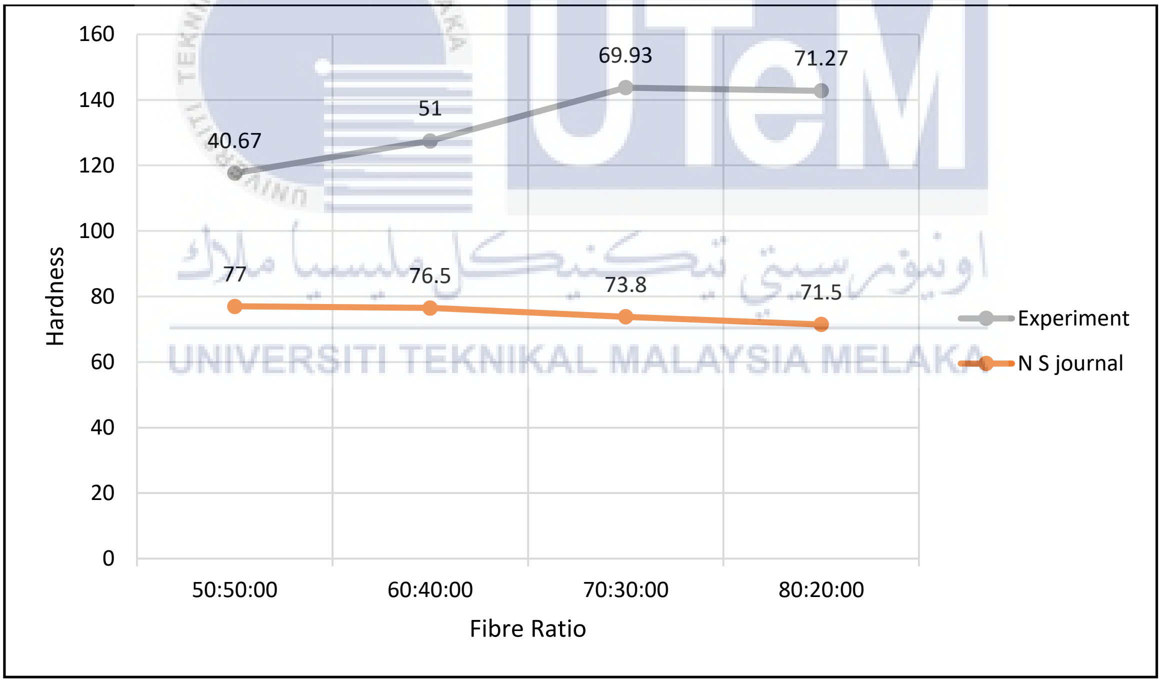


Figure 4.11 : Comparison experiment and Journal

N S Venkatesha Gupta et al's views are grounded on the assumption that density of the fibre effected the hardness strength. From the journal stated that the soft eproxy is used as a reinforcement of the fibre. In any event, the density of the soft eproxy is surely lesser than the fibre and lead to the existing result. The study of the N S Venkatesha et al is an attempt to address that the increasing in the fibre ratio will lead to addition of the hardness strength. The comparison of the existing data and the journal can be observed in figure 4.11. In the figure 4.11, the journal data prove that the maximum hardness is at the fibre ratio of 50:50 with 77 while for the experiment the lowest is position at the fibre ratio 50:50 with only 50.67.

Further evidence can be supported by the Sultan Ozturk's journal that also stated that the increasing in the fibre ratio lead to the increase in hardness strength. However, from the journal also explained that if the density of the synthetic resin material is higher than the fibre, the hardness will be influence by the synthetic resin.

As much as the experimental data that had been observed, the figure 4.9 explained that the theory of the Sultan Ozturk is valid. From the data can be observed that the hardness strength of the composite is increase along together with the decreasing in the fibre ratio. It is opposite with the most journal such as the Y A El Shekeil et al's journal. In the journal mention that the fibre ratio is increasing together with the hardness strength. This is because at low fibre ratio, polypropylene has higher percentage than kenaf and contributed more coverage on fibre.

Differ with the experiment conducted, the density of the polypropylene is $0.92\mathrm{g/cm^3}$ which is higher that the kenaf powder density. Due to that, the hardness strength is major affected by the polypropylene density. When the durometer is contact with the kenaf composite surface, PP can respond positively with the additive and resulted become harder from other fibre. On the basis of the evidence currently available, it seems fair to state that when the resin ratio is increasing, the hardness of the composite will be increase.. Throughout the experiment, for every fibre ratio type have different density range from 0.91 to 0.98 $\mathrm{g/cm^3}$ from highest to lowest fibre ratio. Important to realize that the instability of the density leads to a various data. Figure 4.10 is the complete presentation for this.

As can be seen, every fibre ratio explained a various data. From the data, the best fibre ratio can be choose as a good thermal insulator by following a few crucial properties such as adaption, safety and durability. These properties will be study based on the experimental data in figure 4.9. To begin with, the adaption is crucial in order to reduce the cost. B P Jennel journal is premised on the assumption that lacking in the building site adaptation is a major drawback. To be precise, a thermal insulator need to be a material that can be adjust or cut easily during the installation. This is because the area of the insulator installation is unfixed. For this reason, the lowest value of hardness strength is practically choose as the best thermal insulator. From the analysis can be decided that the fibre ratio of 50:50 that is classified as a hard composite can be a good thermal insulator when it comes to the adaptation properties.

Next, in terms of safety, the most concern issue is the combustion resistance. H R Kymalanen share an important premises regard the fire resistance. Stated in the journal is that fibre is made up of cellulosic material. The cellulosic material is a material that do not resist towards fire. In fact, it is a material that easy to burn. Even the study conduct by Kokkala also proved that the cellulose insulation is more danger than the glass wool. So, reinforcement is needed for this condition. Due to that, in the experiment, the reinforced polypropylene is added to improve the performance of the kenaf composite. The addition of resin affected the hardness strength along with the performance in safety. The Kokkala's findings lend support to the claim that the higher the hardness strength, the better the performance in fire resistance. Among the ratio, only one hardness can perform well in the safety scope which is the lowest fibre ratio, 80:20.

Up to the present time, the performance of the durability on the kenaf composite can be explained by the durometer hardness testing. To install a good thermal insulator, the durability of the composite must be at the top. The thermal insulator is install for a long period of time. So, the thermal insulator must strongly resist towards any wear and damages. Shaikh Faiz Uddin Ahmed et al is prominent in the literature on the properties of the durability on the strain hardening fibre type. Stated in the journal that there are a few crucial properties of durability that can be highlighted such as the performance in hot climate, corrosion resistance and freeze thaw resistance. Among these three properties, only one factors are related to the experiment condition which is the hot climate factors. Corrosion resistance is not valid because the composite do not made up by any metal or steel. In the journal also explained that the addition of fibre to the metal can improve the corrosion resistance. Malaysia is a hot humid country and the freeze thaw is not an issue. However, in terms of performance in the hot climate issue, the composite that has a lower hardness, has lower durability in hot environment. This is stated in the Shaikh Faiz's journal mention that there is a changes in the fibre elastic modulus and fibre strength when the kenaf composite is exposed to the elevated temperature. So, it can be declare that the higher the fibre ratio of kenaf composite leads to low hardness strength and can cause failure due to the low durability properties. It can be conclude that the best composite that can withstand with any wear and damage is the composite of fibre ratio 80:20.

Throughout the hardness testing experiment can be proved that the kenaf composite of 80:20 fibre ratio is leading in terms of safety and quality factors. The currents research appears to validate the view that the higher the hardness strength of the composite, more benefit can be obtained.

CHAPTER 5

CONCLUSION & RECOMMENDATION

Previously, there are many research and past study that have been conduct about the composite of kenaf fibre and the polypropylene polymer. It can be observe from the summary of the journal that has been generate in the chapter 2. When reading and study the journals, a lot of information can be gather about the whole experiment. The comparison of the experimental data and the journals is one of the method in analysing the data. There are some finding that may not be the same as the previous journal such as the relationship on the hardness strength and the fibre ratio. However, by doing a few extra study, the validity of the result and analysis can be verified. Overall, the findings highlight that the concept from the past study are alike as the investigation that has been conduct for kenaf composite. After a few testing, the decision can be made by choosing the kenaf composite that less in the fibre. Through the study, the fibre ratio of 80:20 is proved can be a good thermal insulator for building and houses.

Next, as mention earlier there are four objective that need to be achieve for the projects. In order to achieve it, the test need to be conduct to obtain the actual result. After do some reading on the previous journals, only three method are listed in order to achieve the objective. The three methods can help in deciding the best fibre ratio of composite that can be apply as a thermal insulation for a building. Through the thermal conductivity testing, there are various data obtained. However, to choose a good thermal insulator, the thermal conductivity value need to be low. This is due to the concept of the thermal conductivity is inversely proportional to the thermal insulation. The experimental data explained that a high fibre ratio is needed in order to obtain lower thermal conductivity value. Due to that, kenaf composite of ratio 50:50 is preferred.

For the water absorption testing, a conclusion also has been drawn. Throughout the study, the percentage of the moisture content is observed to be directly proportional to the fibre ratio. From the claim a conclusion can be drawn. To be a good thermal insulator, a low fibre ratio is a must in order to lessen the percentage of the moisture content. In this case the 80:20 ratio kenaf composite is chosen. Next, for the hardness strength testing, many factors are been counts. Among the factors, majority show that the kenaf composite of 80:20 can act as a good thermal insulator after installation. The existing of the previous and current data give a huge impact on the analysis. The knowledge on this thermal and structure can be apply in order to find the best explanation for the result. By comparing with the previous journal, more knowledge on the concept can be obtain. The aim of the study is to choose the best fibre ratio of kenaf composite to act as a thermal insulator and a closer look at these data indicates that the objectives of the project is successfully achieved.

The main objective of the project to find the best ratio of the kenaf composite as a thermal insulator may be achieved. However, there are a few improvement can be made. From the research, the journal of study on the different ratio of a fibre is unfavourable. Due to that, a lot of combination of journal is needed. These also can be a reason on the accuracy of the result. It is suggested that more study and work need to be conduct in future to make as a references. Next as for the fibre ratio, apparently suggested that pure kenaf powder also can be compare. This idea is suggested in order to observe the performance of the pure kenaf without any present of polymer resin. Last but not least, a manufacture company need to do more study on the ntural fibre such as kenaf. This is because natura; fibre can be a very good thermal insulator and it can give huge profit to the company. Any manufacturers must focus in the natural fibre that can give many benefits to people and environments.

REFERENCE

[1] C.H Lee ; S.M Sapuan; M.R Hassan , *mechanical and thermal properties of Kenaf Fibre Reinforced Polypropylene / magnesium hydroxide composite* Vol 12, Issue 2- 2017

[2] V. G Yachmenev; T.A calamari; D.V. Parikh ; *Thermal Insulation properties of kenaf and cotton Non woven composte for automotive application*, 2004

[3] Sergey korniyenko, *Evaluation of thermal performance of residential building envelope* , 1877 -7058

[4]Mohaiman J. Sharba, Zulkefli Leman ; *Effect of Kenaf Fibre orientation on mechanical properties and fatigue life of glass/Kenaf Hybrid composites* , 2016, 1448-1465

[5]Norlin Nosbi,Hazizan Md Akil, Z. A. Mohd Ishak, A. Abu Bakar ; *behaviour of kenaf fibre after immersion in severa; water conditions*; 2011; 950-960

[6]W.H. Haniffah, S.M Sapuan, K. Abdan, M. Khalid, M. Hassan, M. Enamul Hoque ; *Kenaf fibre reinforced polypropylene composites: Effect of cyclic immersion on tensile properties;* Volume 2015

[7]M. A. Maleque, A. Atiqah, R.J Talib, H. Zahurin ; *New natural fibre reinforced aluminium composite for automotive brake pad*; Volume 7 (2012) ; 166-170

[8]M.N Azmi, S.A. Rfeq, R. Nadlene, M.A.M.Irwan, A.M Aishah ; *Tensile and hardness properties of kenaf-pp/pla composite filled nanoclay* ; 2012

[9]Yakubu Dan-Mallam, Tan Wei Hong, Mohd hukry Abd Majid ; *Mechanical characterization and water absorption behaviour of interwoven kenaf/pet fibre reinforced epoxy hybrid composites ;* Volume 2015

[10]N S Venkatesha Gupta et al ; *Fabrication and evaluation of mechanical properties of alkaline treated sisal/hemp fibre reinforced hybrid composite ;* 2016

[11]Y A El-Shekeil , S M Sapuan, K Abdan , E S Zainudin ; *Influence of fiber content on the mechanical and thermal properties of Kenaf fiber reinforeced thermoplastic polyurethane composites ;* 2012

[12]Darshil U Shah, Maximilian C D Bock, Helen Mulligan, Micheal H Ramage ; *Thermal conductivity of engineered bamboo composite;* 2015 ; 2991-3002

[13]S W Kim , S H Lee, J S Kang, K H Kang ; *Thermal conductivity of thermoplastic reinforced with natural fibres*

[14]Monika Z, Jan Terpak, L Dorcak ; *Usage of the ehat conduction model for the experimental determination of thermal diffusivity* ; 2013

[15]Ai Ling Pang, Hanafi Ismail ; *Tensile properties, water uptake, and thermal properties of polypropylene/waste pulverized tire/kenaf composite ;* 2013; 806-617

[16]N S Suharty, Hanafi Ismail, K Diharjo, D S Handayan, M Firdaus ; *Effect of keaf fibre as a reinforcement on the tensile, flexural strength and impact toughness peroperties of recycled polypropylene/halloysite composite* ; 2016; 1876-6196

[17]M J Sharba, Z Leman, M TH Sultan, M R Ishak, M A A Hanim ; *Effect of kenaf fibre orientation on mechanical properties and fatigue life of glass/ kenaf hybrid composite* ; 2016 ; 1448-1465

[18]V G Yachmenev, T A Calamari, D V Parikh ; *Thermal insulation peroperties of kenaf and cotton nonwoven composite for automotive application* ; 2004

[19] N I S Anuar, S Zakaria, J Harun, C Wang ; *Kenaf/PP and EFB/PP : Effect of fibre loading on the mechanical properties of polypropylene composite* ; 2017 ; IOP conference

[20] S S Chee, M Jawaid, M T H Sultan ; *Thermal stability and dynamic mechanical peroperties of kenaf/bamboo fibre reinforced epoxy composite* ; 2017 ; 7118-7132

[21] R G Reid, Oscar M L Asumani, R Paskaramoorthy ; *The effect on the mechanical properties of kenaf fibre reinforced polypropylene resulting from alkali-silane surface treatment* ; 2011 ; 16th international conference on composite structure

[22] X H Loh, M A M Daud, M Z Selamat ; *Mechanical properties of kenaf/polypropylene composite : An investigation* ; 2016 ; Volume 2, Issue 2, 2098-2110

[23] Hafizah, N A K, Hussin, M W, Jamaludin, M Y, Bhutta , M A R, Ismail, Azman ; *Tensile behaviour of kenaf fibre reinforced polymer composite;* 2014 ; eISSN 2180 – 3722

[24] Aoutef LAdhari, Hachmi Ben Daly, Hedi Belhadjsalah, Kenneth C Cole, Johanne Denault ; *Investigation of water absorption in clay-reinforced polypropylene nanocomposites* ; 2010 : 429-439

[25] R. Pomeroy , S. Grove, J. Summerscales, Y Wang, A Harper ; *Measurement of permeability of continuous filament mat glass-fibre reinforcements by satured radial airflow* ; 2007 ; 1439 – 1443

[26] Hazizan Md Akil, Leong Wie Cheng, Z A Mod Ishak, A Abu Bakar, M A Abd Rahman ; *Water Absorption study on pultruded jute fibre reinforced unsaturated polyester composites* ; 2009 ; 1942-1948

[27] S. Yajima, J. Hayashi, M. Omori, K. Okamura ; *Development of a silicon carbide fibre with high tensile strength* ; 1976 ; 683 – 685

[28] Hanna Riita Kyamalainen , Anna – Maoija Sjoberg ; *Flax and hemp fibres as raw materials for thermal Insulations* ; 2008 1261-1269

[29] Fulvio Ardente,Marco Becalli, Maurizio Cellura, Marina Mistretaa ; *Builiding energy performance ; A LCA case study of kenaf-fibres insulation board* ; 2008; 1-10

[30] Cristel Onesipper, Nady Passe Coutrin, Fernando Toro, Silvio Delvasto, Ketty Bilba, Marie-Ange Arsene ; *Sugar cane bagasse fibres reinforced cement composites ; Thermal considerations* ; 2010 ;549-556

[31] Bjorn Petter Jelle ; *Traditional, state of the art and future thermal building insulation materials and solutions – Properties, Requirement and Possibilities* ; 2011 ; 2549-2563

[32] Sultan Ozturk ; *Effect of Fibre Loading on the Mechanical Properties of Kenaf and Fiberfrax Fibre-reinforced Phenil-Formaldehyde Composite* : 2010 ; 2010 44:2265

[33] Shaikh Faiz Uddin Ahmed ; *A review on durability properties f strain hardening fibre reinforced cementitious composites* ; 2007 ; 365-376

[34] P Wambua, Jan Ivens, Ignaas Verpoest : *Natural fibres : Can they replace glass in fibre reinforced plastic?* ; 2003 ; 1259-1264

[35] Asim Shahzad ; *Hemp fiber and its composites – a review* ; 2011 ; 10.1177/0021998311413623

[36] M M Kabir ; *chemical treatments on plat-based natural fibre reinforced polymer composites : An overview* ; 2012 ; 2883-2892

[37] Aouatef Ladhari, Hachmi ben Daly, Hedi Beladjsalah, Kenneth C Cole, Johanne Denault ; *Investigation of water absorption in clay-reinforced polypropylene nanocompsite* ; 2010, 429-439M Idicula

[38] Maries Idicula, Abderrahim Boudenne, L umadevi, Laurent Ibos, Yves Candau, SAbu Thomas ; *Thermoplastic properties of natural fibre reinforced polyester composites* ; 2006 ; 2719-2725

https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjiqJ3do4LYAhWBNo8KHa8rAM0QjhwIBQ&url=https%3A%2F%2Fwww.alibaba.com%2Fproduct-detail%2Fmaize-crusher-maize-crushing-machine-corn_1566940672.html&psig=AOvVaw3aFmxbfQDcA6FgJn1O3N3k&ust=1513092570228304

http://www.simecpellet.com/product/size_reduction_equipment/wood_crusher.html

https://www.researchgate.net/figure/305695122_fig2_Figure-2Schematic-representation-of-the-hot-pressing-machine

https://hort.purdue.edu/newcrop/afcm/kenaf.html https://www.google.com.my/search?biw=1242&bih=602&tbm=isch&sa=1&btnG=Search&q=kenaf+fibre#imgrc=CUHrAm4GSd7EmM:

https://link.springer.com/article/10.1007/s10086-009-1022-8

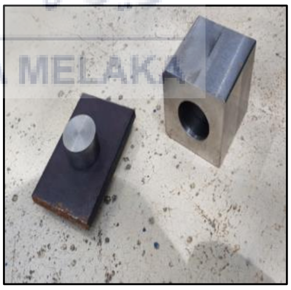
APPENDIX

FABRICATION PROCESS

Internal mixer

Crusher

Hot-press machine



Mold

THERMAL CONDUCTIVITY

Infrared Lamp

Infrared Gun

Sample

WATER ABSORPTION

beaker

Sample

Dry oven

THE HARDNESS TEST

Sample

Hardness Shore D Durometer

GANTT CHART PSM 1

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION
Problem Statement and	1	2	1	2
Literarute Review	3	8	3	8
modification of Project	5	4	5	4
Machinery Study	8	1	8	1
Journal Data Collection	7	7	7	7
Preliminary Result	11	2	11	2
Draft of report writing	9	5	9	5
Report submission	13	1	13	1
Seminar day Presentation	14	1	14	1

PERIODS 1 2 3 4 5 6 7 8 9 10 11 12 13 14

GANTT CHART PSM 2

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION
Conformation of the Title with Supervisor	1	1	1	1
Internal mixer	1	2	1	2
Crusher	3	1	3	1
Hot Press	3	8	3	8
Mold modification	6	1	6	1
Water Absorption	11	1	11	1
Hardness Testing	12	1	12	1
Thermal Conductivity	13	2	13	2
Report and Data Analysis	11	4	11	4
Report Submission	14	1	14	1
Seminar Day 2	16	1	16	1

PERIODS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16